Bulletin of Marine Science

of the

Gulf and Caribbean

VOLUME 10, 1960
NUMBERS 1-4

Published by the University of Miami Press
ISSUED 1961 • CORAL GABLES, FLORIDA, U.S.A.

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OF THE GULF AND CARIBBEAN

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ALPHABETICAL INDEX BY AUTHOR'S NAME

ADAMS, JUDITH A.: A contribution to the biology and post-larval development of the Sargassum fish, *Histrio histrio* (Linnaeus), with a discussion of the *Sargassum* complex. (No. 1, March, 1960) 55

BOURRET, RICHARD AND SAUL BROIDA: Turbulent diffusion in the sea. (No. 3, Sept., 1960) 354

BULLOCK, WILBUR L.: Some acanthocephalan parasites of Florida fishes. (No. 4, Dec., 1960) 481

CAUSEY, DAVID: Parasitic copepoda from Mexican coastal fishes. (No. 3, Sept., 1960) 323

CORRÊA, DIVA DINIZ: Two new marine Turbellaria from Florida. (No. 2, June, 1960) 208

DEUBLER, EARL E.; Salinity as a factor in the control of growth and survival of post larvae of the southern flounder, *Paralichthys lethostigma.* (No. 3, Sept., 1960) 338

GRICE, GEORGE D.: Calanoid and Cyclopoid copepods collected from the Florida Gulf Coast and Florida Keys in 1954 and 1955. (No. 2, June, 1960) 217

GRICE, GEORGE D.: Copepods of the genus *Oithona* from the Gulf of Mexico. (No. 4, Dec., 1960) 485

HUTTON, ROBERT F. AND FRANKLIN SOGANDARES-BERNAL: Studies on helminth parasites from the coast of Florida. II. Digenetic trematodes from shore birds of the west coast of Florida 1. (No. 1, March, 1960) 40

HUTTON ROBERT F. AND FRANKLIN SOGANDARES-BERNAL: Preliminary notes on the life-history of *Mesostephanus appendiculatoides* (Price, 1934)) Lutz, 1935. (No. 2, June, 1960) 234

KLAWE, W. L.: Larval tunas from the Florida Current. (No. 2, June, 1960) 227

LONG, CHARLENE D.: A phoronid from the Gulf of Mexico. (No. 2, June, 1960) 204

LYNN, WALTER A. AND WON TAK YANG: The ecological effects of sewage in Biscayne Bay. Oxygen demand and organic carbon determinations. (No. 4, Dec., 1960) 491

MARCUS, EVELINE AND ERNST: Opisthobranchs from American Atlantic warm waters. (No. 2, June, 1960) 129

MOORE, DONALD R.: *Linckia bullisi,* a new asteroid from the northeast coast of South America. (No. 4, Dec., 1960) 414

MOORE, DONALD R. AND HARVEY R. BULLIS, JR.: A deep-water coral reef in the Gulf of Mexico. (No. 1, March, 1960) 125

ALPHABETICAL INDEX BY AUTHOR'S NAME

MOORE, H. B. AND JOHN C. BAUER: An analysis of the relation of the vertical distribution of three copepods to environmental conditions. (No. 4, Dec., 1960) 430

OWRE, HARDING B.: Plankton of the Florida Current. Part VI. The Chaetognatha. (No. 3, Sept., 1960) 255

PHILLIPS, RONALD C.: Environmental effect on leaves of *Diplanthera* Du Petit-Thouars. (No. 3, Sept., 1960) 346

POMEROY, LAWRENCE R.: Primary productivity of Boca Ciega Bay, Florida. (No. 1, March, 1960) 1

PROVENZANO, ANTHONY J., JR.: Notes on Bermuda hermit crabs (Crustacea; Anomura). (No. 1, March, 1960) 117

RANDALL, JOHN E. AND HELEN A. RANDALL: Examples of mimicry and protective resemblance in tropical marine fishes. (No. 4, Dec., 1960) 444

ROBINS, C. RICHARD: Studies on fishes of the family Ophidiidae. —V. *Lepophidium pheromystax,* a new Atlantic species allied to *Lepophidium jeannae* Fowler. (No. 1, March, 1960) 83

ROBINS, C. RICHARD AND DONALD P. DE SYLVA: Description and relationships of the longbill spearfish, *Tetrapturus belone,* based on western North Atlantic specimens. (No. 4, Dec., 1960) 383

SPRINGER, STEWART AND HARVEY R. BULLIS, JR.: A new species of sawshark, *Pristiophorus schroederi,* from the Bahamas. (No. 2, June, 1960) 241

SPRINGER, VICTOR G.: A new gobiid fish from the eastern Gulf of Mexico. (No. 2, June, 1960) 237

SUAREZ-CAABRO, JOSE AND JUAN E. MADRUGA: The Chaetognatha of the northeastern coast of Honduras, Central America. (No. 4, Dec., 1960) 421

VOSS, GILBERT L. AND NANCY A.: An ecological survey of the marine invertebrates of Bimini, Bahamas, with a consideration of their zoogeographical relationships. (No. 1, March, 1960) . 96

WOODS, LOREN P.: *Chaetodon goniodes,* a new butterfly fish from Puerto Rico. (No. 4, Dec., 1960) 417

YANG, WON TAK: A study of the subgenus *Parahyperia* from the Florida Current (Genus *Hyperia;* Amphipoda: Hyperiida). (No. 1, March, 1960) 11

Regional Bibliography for 1959. (No. 3, Sept., 1960) 367

BULLETIN OF MARINE SCIENCE OF THE GULF AND CARIBBEAN

VOLUME 10 1960 NUMBER 1

PRIMARY PRODUCTIVITY OF BOCA CIEGA BAY, FLORIDA[1]

LAWRENCE R. POMEROY
University of Georgia Marine Institute
Sapelo Island, Georgia

ABSTRACT

The relative importance of turtle grass, phytoplankton, and the benthic microflora as primary producers was determined in Boca Ciega Bay, Florida. In water less than two meters in depth, which makes up 75 per cent of the bay, the three are about equally important. In deeper water only phytoplankton is significant. The methods used and the estimation of community production are discussed.

INTRODUCTION

The importance of various plant populations in the primary productivity of estuaries has been discussed often in the literature, but relatively few investigations of production have included an evaluation of benthic plant production. Blinks (1955) summarized estimates of production of the larger attached algae. Odum and Hoskins (1959) estimated production of benthic flora in some Texas bays, and Odum (1956) estimated production of *Thalassia* during one day at Long Key, Florida. Smalley (1959) estimated the production of *Spartina alterniflora* and Pomeroy (1959) estimated the production of the benthic microflora in the marshy estuaries of Georgia. In the present study the relative importance as producers of the various plant populations in Boca Ciega Bay, Florida, was investigated.

Boca Ciega Bay is a shallow lagoon formed behind barrier beaches. Its area is 100 km^2 and its mean depth is 1.5 m. Shallow beds of marine spermatophytes, principally *Thalassia testudinum* König and *Syringodium filiforme* Kutz (Thorne, 1954), make up about 75 per cent of its area. The remainder consists of tide-cut channels with bare, sandy bottoms. The water of Tampa Bay, and probably of Boca Ciega

[1]Contribution No. 15 from the Marine Institute of the University of Georgia, Sapelo Island, Georgia. This research was supported by funds from the Georgia Agricultural and Forestry Research Foundation.

Bay with which it joins, is relatively rich in dissolved phosphorus (Odum, 1953). Planktonic chlorophyll *a* has been estimated in the region by Marshall (1956).

Methods

Production of phytoplankton was estimated by the light-and-dark-bottle method (Gaarder and Gran, 1927). Water was collected at several depths and returned to approximately the same depth in 400-ml citrate bottles. Because production was moderately high, significant changes in dissolved oxygen took place in a short time, and no bottle experiment lasted over five hours. To estimate *Thalassia* production individual plants were placed in citrate bottles filled with bay water and were held at several depths for periods of two to four hours. At the end of the exposure period the plants were carefully removed with a minimum of agitation of the water, and the change in dissolved oxygen in the water was measured. The results were corrected for photosynthesis of phytoplankton in the bottles. Production and respiration of the aufwuchs on *Thalassia* was estimated by comparing the change of dissolved oxygen in bottles containing plants stripped of aufwuchs with that in bottles containing unmodified plants. The term, aufwuchs, is used here to mean the assemblage of plants and animals attached to the leaves of *Thalassia* and other marine spermatophytes.

Production of benthic microflora was estimated by pressing bell jars into the sediments and measuring changes in dissolved oxygen in the water enclosed in the jars. The bell jars and the technique of using them have been described elsewhere (Pomeroy, 1959). The water in the bell jars was not stirred as previously described, because the jars could not be reached at all times. For purposes of comparison some of the bell jars were placed over undisturbed *Thalassia* and *Syringodium*.

Some estimates of total community production were made by the method of Odum (1956) by taking serial measurements of dissolved oxygen at a single station over *Thalassia* beds and preparing an oxygen rate-of-change curve, corrected for diffusion across the surface of the water and for community respiration. The sampling periods were during daylight, and respiration was estimated from the bottle and bell-jar experiments.

Incident light and transparency of the water were measured with a multi-range submarine photometer (built by L. V. Whitney), which

employed a Weston photocell. Radiation estimates are of photosynthetically active radiation, which is assumed to be 50 per cent of total radiation at the sea surface. Radiation is reported in langleys per unit time (Strickland, 1958).

The distribution of the *Thalassia* and *Syringodium* beds was studied by running transects across Boca Ciega Bay along which the boat was stopped at timed intervals and the depth and presence of vegetation were recorded. The density of *Thalassia* was estimated from a series of 0.25 m^2 quadrats from which all leaves and rhizomes were collected. The quadrat study was limited to water less than one meter in depth and is assumed to be representative only of the area studied and not necessarily of the entire bay.

The chlorophyll content of the phytoplankton was determined by the method of Creitz and Richards (1955). The chlorophyll content of *Thalassia* was determined by drying leaves in a vacuum dessicator at 4°C, grinding them in a mortar, extracting the leaves four times with 90 per cent acetone, and estimating the chlorophyll concentration by the method of Richards and Thompson (1952).

Observations

The mean density of *Thalassia* was found to be 60 $\pm$ 13 plants/ m^2 in the study area on the basis of seven 0.25 m^2 samples. The mean dry weight of *Thalassia* from the quadrat samples was 81 $\pm$ 7.5 g/m^2, of which 40 per cent was leaves. The chlorophyll *a* content of *Thalassia* was estimated to be 1.7 mg/g of leaves (dry weight) or about 54 mg/m^2 of the *Thalassia* beds. A transect survey involving 60 stations showed that in water one meter or less in depth (mean low water) some rooted plants were always present. However, the density of plant cover varied greatly. In water two meters or more in depth rooted plants were not found in Boca Ciega Bay.

In bottle experiments *Thalassia* production showed an essentially linear relation to the intensity of radiation reaching the plants (Fig. 1). By combining the results of the bottle experiments with those of the quadrat study and the survey of *Thalassia* distribution, it was possible to estimate the production of *Thalassia* at any depth. Such an estimate is included in Figure 2. When bell jars were placed over *Thalassia* the rate of photosynthesis was only slightly higher than when the bell jars were placed over sediments which were bare except for the microflora. The mean rate of gross photosynthesis of the benthic microflora alone was 130 $\pm$ 30 mg O_2/m^2/hr, while that of the micro-

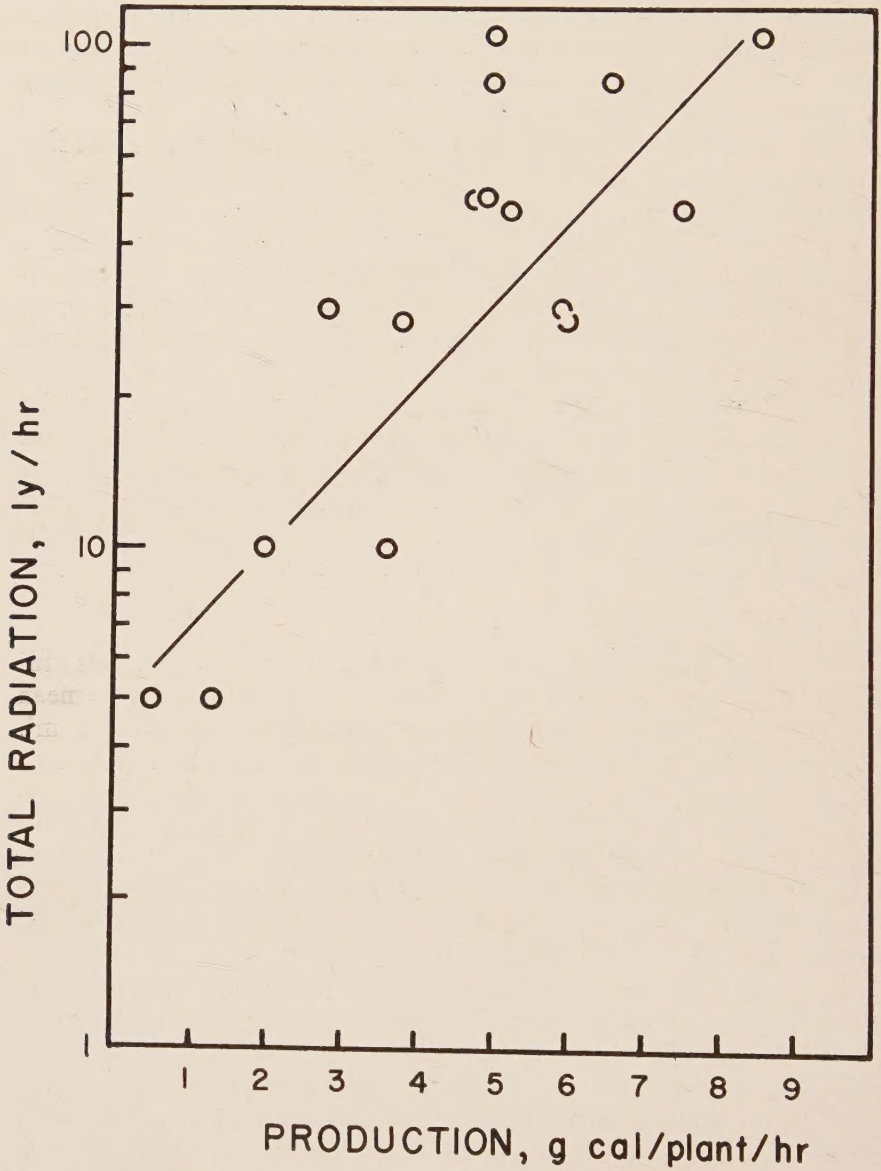

FIGURE 1. Bottle experiments on the relation of photosynthesis of *Thalassia* to light intensity, May 8 and 10, 1958. Water temperature varied from 18 to 22°C. Line of best fit, calculated by least squares: log Y = 0.68 + 0.164X. Light intensity given as total radiation. Photosynthetically active radiation = 0.5 total.

TABLE 1

ESTIMATES OF PRODUCTION OF *Thalassia* AND BENTHIC MICROFLORA BENEATH BELL JARS.

Location	Date 1958	Exposure period	Populations present	light or dark	Depth, meters	Radiation at bottom, ly/hr	mg $0_2/m^2/hr$
27°39.7′N 83°43.0′W	9-30	0813-1015	microflora	L	0.4	9.4	+82.
		1025-1225	microflora	L	0.6	24.	+162.
		1235-1405	microflora	L	0.7	22.	+118.
		0831-1255	microflora	D	0.5	0	—69.
		0825-1030	microflora, *Thalassia*	L	0.4	9.	+233.
		1040-1240	microflora, *Thalassia*	L	0.6	24.	+233.
		1250-1420	microflora, *Thalassia*	L	0.7	22.	+134.
27°41.1′N 83°43.0′W	9-27	0750-0950	microflora, *Thalassia*	L	0.5	4.	+95.
		1010-1210	microflora, *Thalassia*	L	1.0	20.	+318.
		1215-1415	microflora, *Thalassia*	L	1.0	20.	+201.

TABLE 1—Continued

ESTIMATES OF PRODUCTION OF *Thalassia* AND BENTHIC MICROFLORA BENEATH BELL JARS.

Location	Date 1958	Exposure period	Populations present	light or dark	Depth, meters	Radiation at bottom, ly/hr	mg $0_2/m^2/hr$
27°41.1′N	9-27	0805-	microflora,	D	0.5	0	—73.
83°43.0′W		1405	*Thal., Syrin.*				
(cont)		0820-	microflora,	L	0.5	4.	+101.
		1020	*Syringodium*				
		1035-	microflora,	L	1.0	14.	+6.
		1235	*Syringodium*				
		1245-	microflora,	L	1.0	8.	—47.
		1445	*Syringodium*				
27°40.3′N	5-10	1000-	microflora	L	0.6	35.	+61.
83°43.3′W		1200					
		1020-	microflora	D	0.6	0	—21.
		1220					
		1030-	microflora	L	0.6	35.	+26.
		1230					
27°39.6′N	5-8	1045-	microflora,	L	0.5	30.	+148.
83°43.3′W		1245	*Thalassia*				
		1100-	microflora,	D	0.5	0	—28.
		1300	*Thalassia*				
		1115-	microflora	L	0.5	30.	+50.
		1315					

flora plus *Thalassia* was 210 ± 35. These means differ only at the 68 per cent confidence level, and a larger sample would be necessary to decide with real assurance whether shallow bottoms with *Thalassia* on them are really more productive than those without it.

Respiration under bell jars covered with black polyethylene film appeared, from the very small sample (Table 1), to be the same whether or not *Thalassia* was enclosed, and the mean of five measurements was 47 ± 8 mg $0_2/m^2/hr$. This suggests that the amount of respiration of the autotrophic organisms is low in comparison with that of the heterotrophic organisms in the sediments.

The rate of photosynthesis of *Thalassia* leaves stripped of aufwuchs was not different from that of unmodified leaves. Neither was the respiration of stripped leaves different by a measurable amount.

Phytoplankton production was measured on May 8 and 10 and September 24, 27, and 30, 1958. The results are combined in Figure 2. The concentration of chlorophyll *a* in the phytoplankton varied from 0.8 to 3.5 mg/m^3. Production of phytoplankton, *Thalassia,* and benthic microflora are combined in Figure 2 to suggest the relative importance of the various autotrophic populations. Estimates of total primary production by Odum's (1956) method range from 0.7 to 2.0 g $0_2/m^2/hr$.

The transmission coefficient of the bay water varied from 0.76 to 0.90 during May, 1958 and from 0.44 to 0.53 in September, 1958. All observations of transparency were made on relatively calm days, so the mean transmission coefficient for all weather conditions may be more than 1.0.

Discussion and Conclusions

When community production is estimated by the method of Odum (1956) it proves to be greater than the combined estimates from bottle and bell-jar experiments as shown in Figure 2. Hoskins and Odum (1959) also found that results of bell-jar studies were lower than estimates based on observed changes of dissolved oxygen concentration in the open water. They concluded that bell-jar observations are too low because there is not a natural amount of water movement in the bell jars. This has been found to be true of bottle experiments also (Doty and Oguri, 1958), and shaking or stirring devices are necessary if true estimates of photosynthesis in nature are to be made by means of bottle experiments. The principal concern of this communication is with the relative importance of various plant popula-

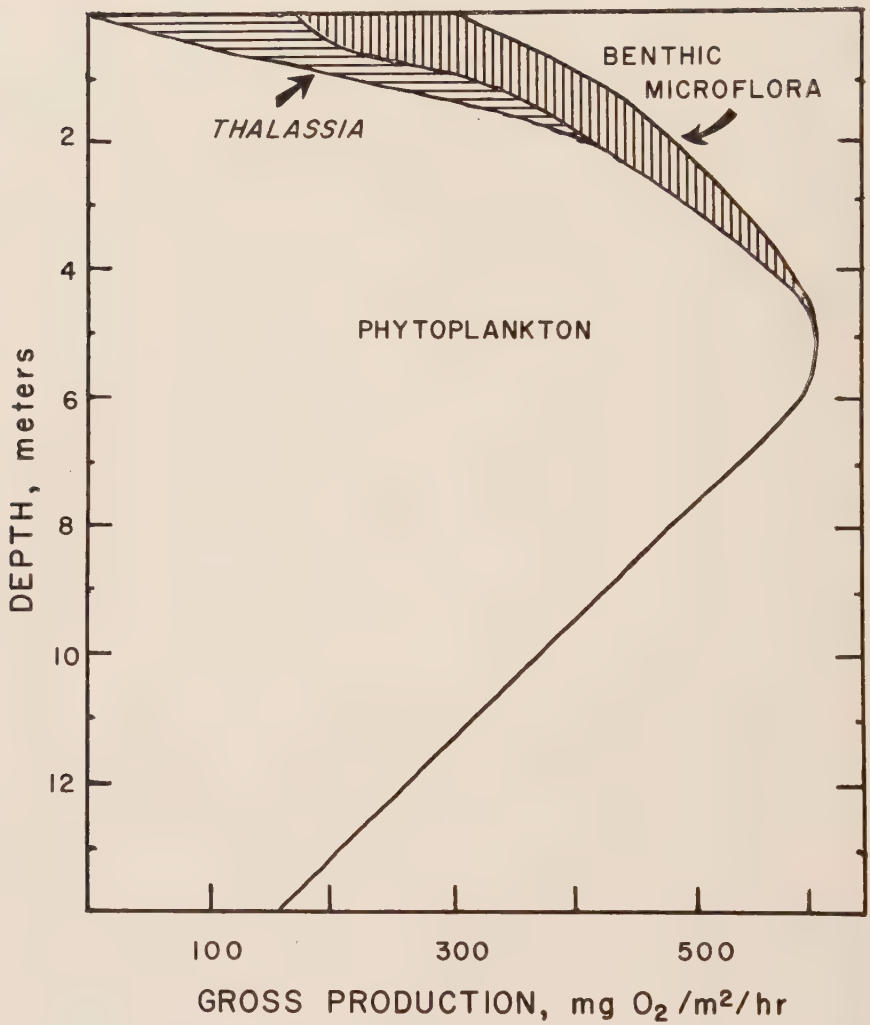

FIGURE 2. Variation with depth of the relative primary production of the plant populations in Boca Ciega Bay. Most of the bay is less than two meters deep.

tions, and for this purpose the bottle and bell-jar observations provide comparable relative estimates. Therefore, the values in Figure 2 are relative ones. From the few measurements of change of dissolved oxygen in the bay water the gross community production appears to be on the order of 5 g $0_2/m^2/day$.

The relative importance of phytoplankton, marine spermatophytes, and the benthic microflora as primary producers varies with the depth of the water. In water less than two meters in depth, which makes up 75 per cent of Boca Ciega Bay, all three are of about equal importance. In deeper water benthic plants are unimportant, and all production is planktonic. The compensation depth for phytoplankton is from five to seven meters. The critical depth (Sverdrup, 1953) probably is never less than 25 meters and is typically much deeper. Therefore, the entire bay is productive throughout the year, with greatest productivity in water between one and seven meters in depth.

The bottle experiments with *Thalassia* show that its photosynthesis is not inhibited by strong illumination as is that of phytoplankton, so it is most productive in very clear, shallow water. The bottle experiments suggest that the compensation depth for *Thalassia* should be at four meters. However, no *Thalassia* was found below two meters. Probably the mean transparency of the water is less than that observed during the experiments.

Bell-jar observations on sediments bare of macroscopic plants show that the benthic microflora are important producers. Because all observations were made in water less than two meters in depth, the compensation depth for this population was not determined experimentally. Probably it is about the same as that of phytoplankton, and this was assumed in the estimates given in Figure 2. No attempt was made to determine the taxonomic makeup of the benthic microflora. This has been done in a number of other places (Aleem, 1949; Callame and Debyser, 1954; Smyth, 1955; Moul and Mason, 1958; Pomeroy, 1959), and the dominant organisms have been found to be diatoms in most cases.

In bell-jar observations with *Thalassia* and *Syringodium* beneath the bell jar the rate of production tended to be greater than in observations over the microflora alone, but only slightly so. However, the bottle experiments show *Thalassia* to be an important producer. It is possible that *Thalassia* shades the microflora beneath it, reducing the rate of photosynthesis of the latter. If this is so, then all shallows in Boca Ciega Bay are about equally productive whether they are covered by marine spermatophytes or not.

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A STUDY OF THE SUBGENUS *PARAHYPERIA* FROM THE FLORIDA CURRENT (GENUS *HYPERIA*; AMPHIPODA: HYPERIIDA).[1]

WON TACK YANG
Fisheries Department, Pusan, Korea

Abstract

Five species of the subgenus *Parahyperia* (genus *Hyperia)* are studied from eighty tows from Scattering Layer Stations in the Florida Current. *Hyperia (P.) schizogeneios, H. (P.) macrophthalma* and *H. (P.) atlantica* are removed from the synonomy of *H. (P.) bengalensis.* The development of the male of *H. (P.) schizogeneios* is described. The male of *H. (P.) macrophthalma,* the female of *H. (P.) macrodactyla,* and the young female of *H. (P.) atlantica* are described.

Introduction

The present paper is a study of the genus *Hyperia* (subgenus *Parahyperia*) of the hyperiidean Amphipoda collected from the Florida Current by the University of Miami Research vessel GERDA during three cruises.

Due to morphological similarities as well as inadequate original descriptions of some species of this group, there has been a tendency toward lumping species since Stephensen's work in 1924. Pirlot (1939) placed 11 described species into the synonomy of *Hyperia bengalensis* (Giles). This was accepted by Shoemaker (1945) and Hurley (1955), Reid (1955) split *H. bengalensis* into *H. bengalensis* (Giles) and *H. latissima* Bov., giving four discriminating characters. The previous tendency has obscured many species, and detailed study is now needed to establish their validity. Confusion in this group seems to have been caused by the ontogenetic changes in the degree of fusion of the pereods and the marked sexual dimorphism in some species. Thus males and females of the same species have been described under separate names. The taxonomic criteria used by the early workers in this group must be re-evaluated by extensive study of the immature stages. A revision of the genus is urgently needed.

The present work deals with five species of the subgenus *Parahyperia.* Two new forms of this group also occurring in the Florida Current are not included in the present paper, since they are being described by Dr. Thomas E. Bowman of the United States National Museum.

[1]Contribution No. 232 from The Marine Laboratory, University of Miami.

The Florida Current, compared to the Central and Eastern Atlantic, is an amazingly unexplored area as regards the hyperiidean fauna. Bovallius (1887-1889) mentioned few species of this group from the tropical Atlantic and Caribbean Sea. Vosseler's work (1901) did not cover this region. The works which are closely related to this region are Shoemaker's of Bermuda (1945), and of Cuba (1948).

The author thanks the authorities of the Division of Marine Invertebrates of the United States National Museum for many kindnesses extended him during his visit there. He is especially indebted to Dr. Thomas E. Bowman of that institution for his unselfish guidance and for permission to utilize part of his extensive unpublished manuscript. He is also grateful to Mr. Clarence R. Shoemaker for the use of his private collection of Amphipoda literature. Dr. Hilary B. Moore has made available material from the Scattering Layer Stations. Dr. Gilbert L. Voss directed the studies and offered numerous suggestions. The author also thanks Dr. C. Richard Robins and Mr. Thomas W. McKenney for helping him with the manuscript. Mr. Walter Erman has generously provided financial aid during the writer's term of study at the Marine Laboratory.

Materials, Methods and Terminology

The specimens studied in this paper were obtained at the following Scattering Layer Stations (SL).

STATIONS	DATE	LOCATION		DEPTH RANGE (M)	NUMBER OF TOWS
SL 40	Oct. 4, 5, 1955	25°33′N. 79°59′W.	The West side of the Florida Current	0-492	35
SL 41	Oct. 17, 18, 1955	25°33′N. 79°50′W.			34
SL 51	Mar. 18, 19, 1958	25°33′N. 79°25′W.	The East side of the Florida Current	0-700	11

The plankton nets used in the collections were 70 cm Discovery-type closing nets, divided into three parts of equal length. The leading portion was of ¼ inch mesh, the middle of stramin, followed by No. 10 silk bolting cloth.

The measurements given in this paper are from the front of the head to the end of the urosome.

Some of the figures of the appendages in the plates were drawn while the appendages were under a coverglass in glycerin-alcohol solution.

The following abbreviations are applied in the keys, illustrations and descriptions to conserve space:

ant. 1	first antenna.
ant. 2	second antenna.
md.	mandible.
mx. 1	first maxilla.
mx. 2	second maxilla.
maxp.	maxilliped.
p. 1-7	first to seventh pereopods.
up. 1-3	first to third uropods.
ups.	uropods.
s. 1	coxopodite, coxal plate, or side plate.
s. 2	basipodite or femur.
s. 3	ischiopodite or ischium.
s. 4	meropodite or merus.
s. 5	carpopodite or carpus.
s. 6	propodite, propodus or metcarpus.
s. 7	dactylopodite or dactyl.

The terms "pereon" and "pereopod," and "pereod" and "pleod" which were adopted by Steinberg and Dougherty (1957) were used instead of "peraeon" and "peraeopod," and "peraeon somite" and "pleon somite."

Suborder HYPERIIDEA
Superfamily Genuina Woltereck, 1909
Division *FILICORNIA* Bovallius, 1890
Family HYPERIIDAE Dana, 1852
Genus *Hyperia* Latreille, 1823

Hyperia Latreille; Bovallius, 1889, p. 129; Vosseler, 1901, p. 56 (subgenera *Hyperia* and *Parahyperia);* Stebbing, 1888, p. 1377; Stephensen, 1924, p. 80; Chevreux and Fage, 1925, p. 400; Pirlot, 1929, p. 120; Shoemaker, 1945, p. 238; Bowman, 1953, p. 192; Hurley, 1955, p. 137; Irie, 1957, p. 350.

Lestrigonus Milne-Edwards, 1830, p. 392.

Diagnosis. Head deeper than long; pereon more or less dilated in female. Md. with serrated molar process; palp sometimes missing in female. P. 1 subchelate or barely chelate; carpal process only slightly developed. P. 2 Chelate; carpal process spoon-shaped, bearing spines along the edge of the "spoon." None of the pereopods greatly elongated. (After Bowman, 1953).

Subgenus *Parahyperia* Vosseler, 1901

Diagnosis. Md. palp absent in female. Some of pereods fused. Ped-

uncle of ant. 1 one-segmented. Female ant. 2 usually rudimentary, not in *macrodactyla*. S. 5 and 6 or p. 1 and 2 with only a few spines. P. 5-7 as long as, or longer than, p. 3-4, slightly shorter in *macrodactyla*. Small species, 3-6 mm (After Bowman, 1953).

It seems very reasonable from the viewpoint of the morphology as well as the mode of life and geographical distribution to divide the genus *Hyperia* into the two subgenera, *Hyperia* and *Parahyperia,* as was proposed by Vosseler (1901) and accepted by Bowman (1953).

Key to the Species of the Subgenus *Parahyperia* found in the Florida Current

1. P. 5 much shorter than p. 6-7. S. 2 of p. 1 greatly dilated (Fig. 9, D), about two times broader than that of p. 2. With many large spines on anterior margin of s. 4, 5 and 6 of p. 5-7. Telson very short. . . . *H. (P) macrodactyla*
   P. 5 normal, as long as, or a little longer than p. 6-7. S. 2 of p. 1 not as much dilated as the above. Without large spines on s. 4, 5 and 6 or p. 5-7. 2
2. S. 2 of p. 5-7 considerably wider than half its length. Head much deeper than long, 2 large spines on hind margin of s. 5 of p. 3-4. . . . . *H. (P.) fabrei*
   S. 2 of p. 5-7 considerably less than half its length. Head not much deeper than long. Without two large spines on hind margin of p. 5 of p. 3-4 3
3. Flagellum of ant. 1 multi-segmented, males. 4
   Flagellum of ant. 1 single-segmented, females. 5
4. Pereods 1-2 slightly fused dorsally (Fig. 2, A). Ventral process of head pointed (Fig. 2); almost reaching mouth-parts; ribbed. Width of peduncle of up. 3 about three times its length. Apex of telson slender posteriorly; acutely pointed (Fig. 1, G). . . . . *H. (P.) schizogeneios*
   Pereods 1-2 or 1-4 completely fused dorsally (Fig. 5, A. 6, A). Ventral process of head rounded (Fig. 5, A. 6, A); not reaching mouthparts. Width of peduncle of up. 3 less than three times its length. Apex of telson rounder; not acutely pointed. 5
5. Lateral profile of head convex (Fig. 5, A). Pereods 1-2 fused dorsally. Apex of telson slightly pointed (Fig. 5, O). Lateral margins of up. 2 peduncle nearly parallel (Fig. 5, O). P. 6-7, armed with a spine at the inner distal end of s. 6; no hairs on the crook of dactyl of p. 6-7 (Fig. 5, L and M). . . . . *H. (P.) macrophthalma*
   Lateral profile of head forming right angle (Fig. 6, A). Pereods 1-4 dorsally fused. Apex of telson rounded; not pointed. Lateral margins of peduncle of up. 2 narrow at proximal (Fig. 6, K). P. 5-7 armed with hairs on the crook of dactyl, no spine present (Fig. 6, G, H). . . . . *H. (P.) atlantica*
6. Pereods 1-3 dorsally fused (Fig. 3, A). Ventral process of head pointed; reaching mouthparts, ribbed. . . . . *H. (P.) schizogeneios*
   Pereods 1-4, or 1-5 dorsally fused. Ventral process of head rounded; not reaching mouthparts. 7
7. Profile of head globular, swollen. (Fig 4, A). Pereods 1-4 fused dorsally. P. 6-7 armed with a small spine at the inner distal end of s. 6, generally no hairs on the crook of dactyl of p. 6-7. . . . . *H. (P.) macrophthalma*
   Profile of head slightly globular, confluent with pereon (Fig. 7, A). Pereods

1-5 fused dorsally. No spine at the end of s. 6 of p. 6-7, generally armed with hairs on crook of dactyl of p. 6. ..... *H. (P.) atlantica*

Hyperia (Parahyperia) schizogeneios Stebbing, 1888
Figs. 1-3

Hyperia schizogeneios Stebbing, 1888, p. 1391, pl. 168; Bovallius, 1889, p. 221; Chevreux 1900, p. 139, pl. 17, fig. 1 (a-m); Vosseler, 1901, p. 66; Stephensen, 1924, p. 86; Chevreux et Fage, 1925, p. 403, fig. 402; Pirlot, 1929, p. 120; 1930, p. 16; Bulycheva, 1955, p. 1048; Irie, 1957, p. 350, fig. 12.

Hyperia promontorii Stebbing, 1888, p. 1385, pl. 165; Vosseler, 1901, p. 64; Barnard, 1930, p. 441.

Hyperia promontorii Stebbing, (?); Dakin and Colefax, 1940, p. 121, fig. 206.

Hyperia bengalensis (Giles) (?); Pirlot, 1939, p. 35; Shoemaker, 1945, p. 238; Reid, 1955, p. 16-17.

Diagnosis. Lateral profile of head rounded antero-dorsally, about twice as high as long, with clearly sharp-pointed ventral process (Fig. 2-3, A). P. 1, s. 2 with the anterior margin a little convex,

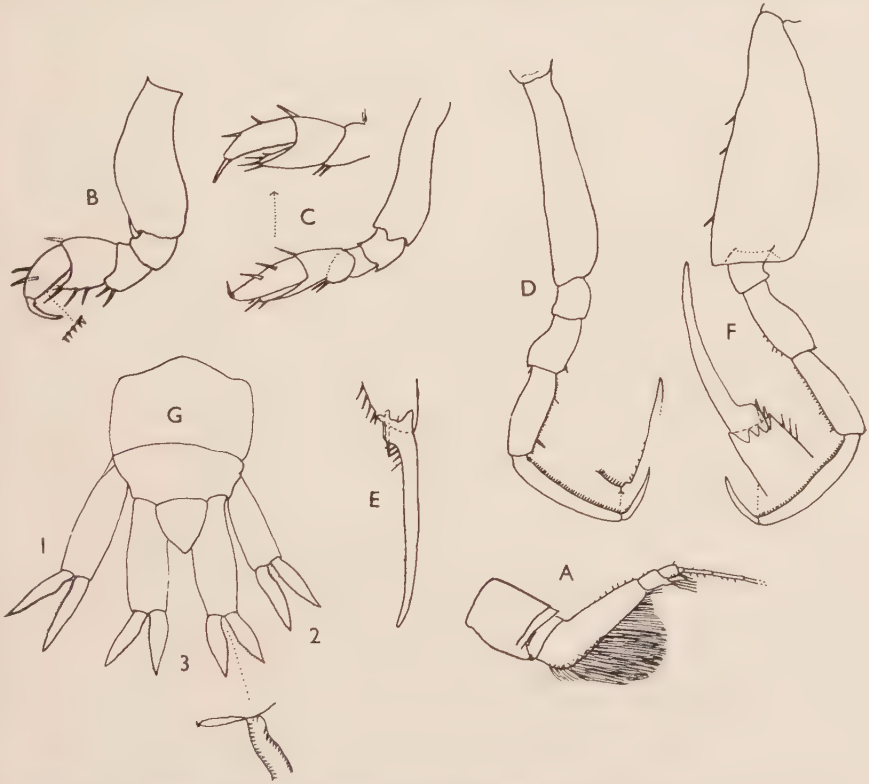

FIGURE 1. *Hyperia (P.) schizogeneios* Stebbing. Male—A. ant. 1; B. p. 1; C. p. 2; D. p. 3; E. s. 5 and 6 of p. 5; F. p. 7; G. ups.1, 2 and 3.

dilated at the middle; the carpal process of s. 5 extends less than one-half way along the finely serrated hind margin of s. 6. P. 5-7 about equal in length; s. 2 a little dilated; ratio of lengths s. 5 to s. 6 is even or at most 4:5. *Adult female,* pereons 1-3 dorsally fused. The ventral process of head reaches below the mouthparts. S. 6 of p. 1 and 2 usually with 1 spine (rarely 2 spines) on the antero-internal margin. S. 5 of

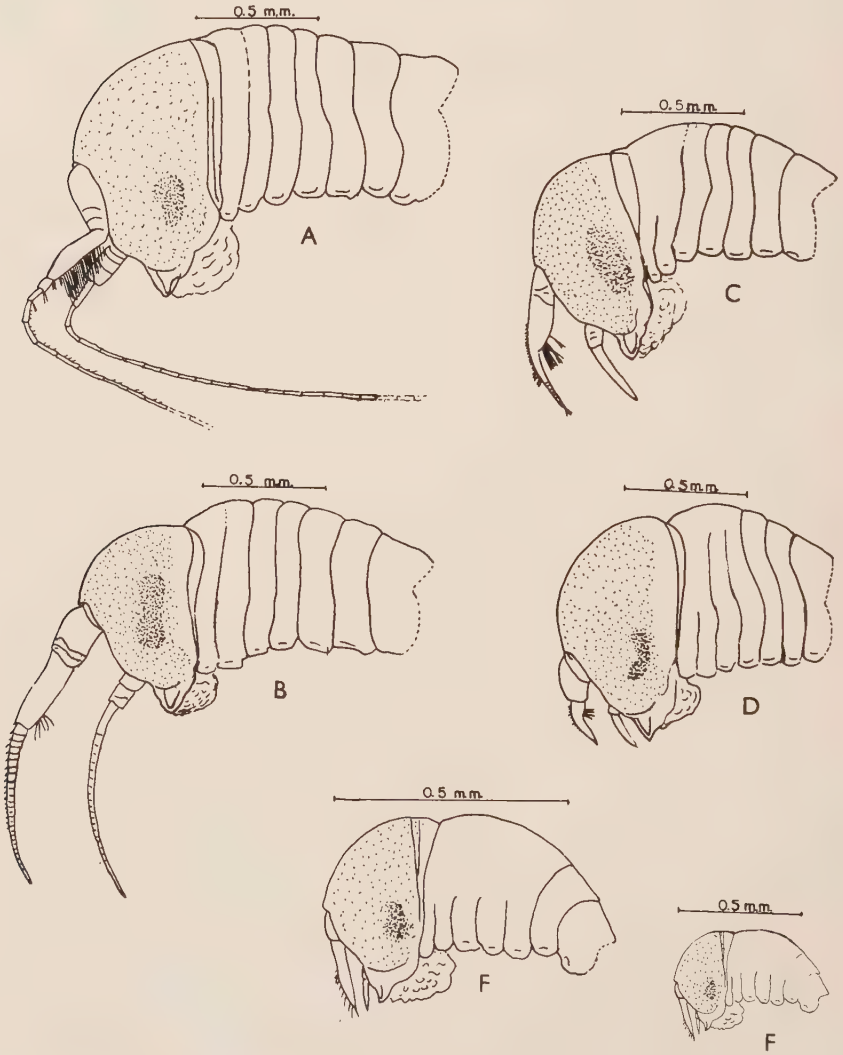

FIGURE 2. *Hyperia (P.) schizogeneios* Stebbing. Male—Different Stages (A-F).

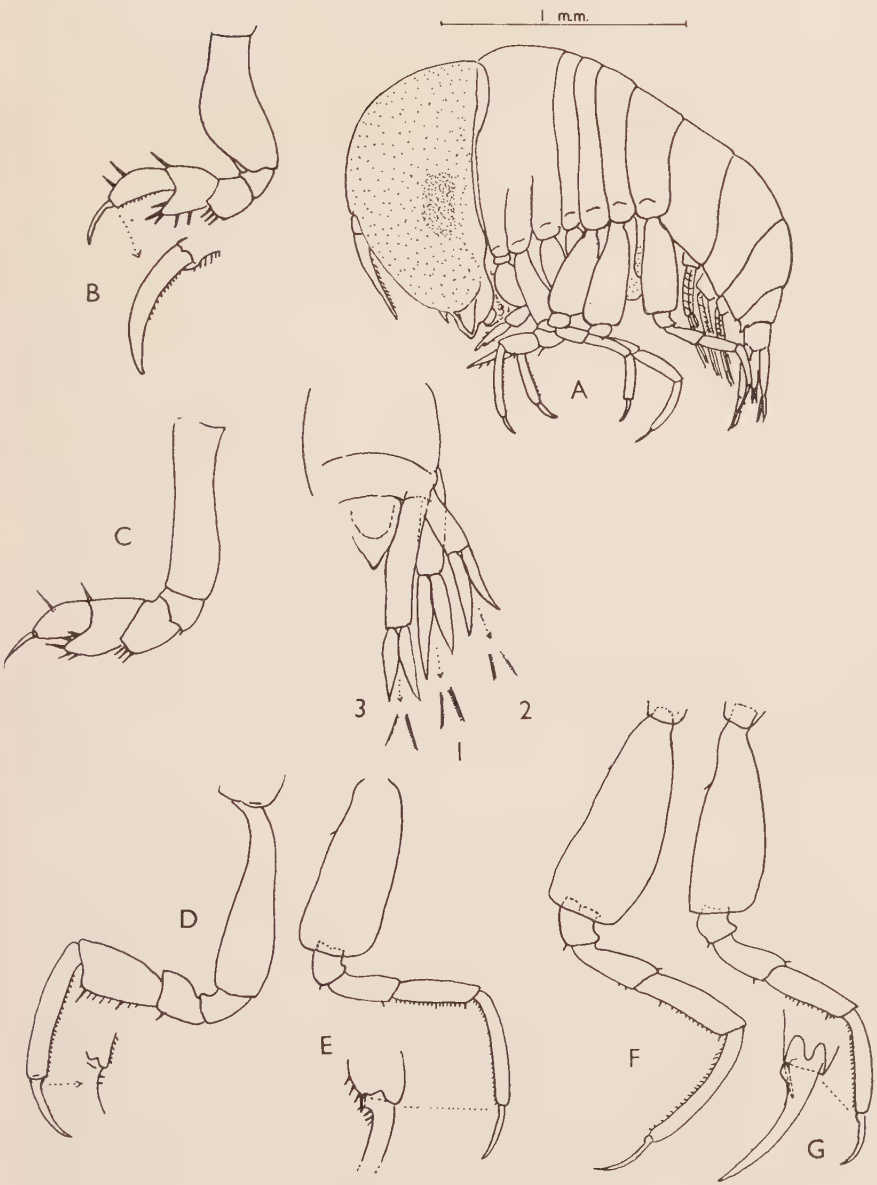

FIGURE 3. *Hyperia (P.) schizogeneios* Stebbing. Female—A. Lateral view of animal; B. p. 1; C. p. 2; D. p. 3; E. p. 5; F. p. 6; G. p. 7.

p. 2 extends about half-way along the hind margin of s. 6. *Adult male,* pereods 1-2 slightly fused dorsally. The ventral process of head not produced as far as in the female. S. 6 of p. 1-2 usually has two spines on the antero-internal margin. S. 5 of p. 2 extends a little more than half-way along the hind margin of s. 6. The peduncle of up. 3 about three times longer than wide and less than two times the length of the rami (Fig. 1, G).

Length. Male 4 mm, female 3.5 mm.

Distribution. Mediterranean, Atlantic (47°N.-45°S. ?), Pacific Ocean.

Observations on the ontogenetic development of the male. As noted by Chevreux (1900, p. 142) in the male and Stephensen (1924, p. 88) in the female, the number of fused pereods is greater in the younger stages. Stephensen (1924) stated that in small or comparatively small females, 1-4 or even 1-5 pereods are sometimes fused. All the young stages of the females of this study agree with these statements.

As to the younger stages of the male, Chevreux (1900) mentions an example of a young specimen which seems to be a stage between B and C in the following table. A general study has been made of 21 male specimens from SL stations and the developmental stages are shown in Table 1 and Fig. 2, A-F.

In summary, the following points should be noted:

1. In the younger male, with short antennae, the ventral process is more produced so that the head profile is closer to that of the female.
2. As pointed out by Chevreux (1900, p. 141) the uropods of the young male are similar to those of the female.
3. The younger the animal, the greater the degree of fusion of pereods, with a maximum of 1-5 fused.
4. For the preceding reasons, as Bowman (1953) pointed out, Bovallius' key to the *Parahyperia* is not applicable for an identification of the young, but only for adults.

Remarks. The female figures here agree closely with Stebbing's (1888) descriptions and figures of *H. schizogeneios.* The male also agrees closely with the description of Chevreux (1900, p. 139-143, pl. 17, fig. 1) except for the following points:

1. The ventral process of the head in Chevreux's figure is extremely sharp. This may be a schematic picture to emphasize the ventral process of the head.
2. Chevreux (p. 141) described the hind margin of s. 6 of p. 2 as smooth while, on my specimens, this margin is slightly serrated.

Discussion. 1. Concerning the spination of s. 6 of p. 1 and p. 2 of the male, Stephensen (1924, p. 87) mentioned that the number of spines is different in some individuals. I have examined 21 male specimens (including young) and also found these differences. One specimen from SL 51 has 3 spines.

2. Since Pirlot's (1939) paper, the tendency has been to place less emphasis on the number of pereods fused in the classification of this group. Hurley (1955, p. 140) states: "The degree of fusion of the body segments appears from Pirlot's synonymy to be no longer accepted as a valid species characteristic for this genus." As mentioned above, I believe that the number of pereods fused is definitely an important character. It is considered definitely proper to remove *H. schizogeneios* Stebbing from Pirlot's lumped synonymy of *H. bengalensis* (Giles).

3. Without mentioning pereod fusion, Reid (1955, p. 16) divided Pirlot's *H. bengalensis* (Giles) into *H. bengalensis* and *H. latissima.* Aside from *H. latissima,* the species that he called *H. bengalensis* seems to be *H. schizogeneios* from his four given character differences. It is difficult to give a criticism of another's work without seeing the specimens. However, there is no known species in which the ventral process of the head is sharply pointed in this group except for *H. schizogeneios.* The original description and figures of *H. bengalensis* (Giles 1887, pp. 224-227, pl. 6 and 7) clearly show no sharp ventral process of the head in both male (all pereods free, 2.5 mm) and female (the last two pereods free, 1.75 mm).

Hyperia (Parahyperia) macrophthalma Vosseler, 1901

Figs. 4-5

Hyperia macrophthalma Vosseler, 1901, p. 70-72, 75-76, pl. 6, fig. 16-25.
Hyperia macrophthalma Vosseler Stephensen, 1924, p. 92-93.
Hyperia latissima Bov. (?) Chevreux et Fage, 1925, p. 404, fig. 403.

Diagnosis. Lateral profile of head large with a rounded ventral process; about as long as the first five pereods; higher than the pereon. *Female,* head globular, pereods 1-4 dorsally fused; pereon somewhat inflated. P. 1: s. 2 much dilated a little above the middle; the posterior margin of s. 5 with one spine; the process of s. 5 reaching a little less than one-half the length of s. 6; s. 6 with one spine on the anterior border. P. 2 with a spine on the anterior border of s. 6; process of s. 5 reaching a little beyond one-half the length of s. 6. S. 2 of p. 5-7 not extremely slender proximally. The length of s. 3 and 4 combined almost equal to s. 5 in p. 5-6. The last pleod as long as one-half of the

first urosome segments in length. Telson semitriangular, shorter than one-half of the length of the peduncle of up. 3. The peduncle of up. 1 about as long as that of up. 3. *Male,* similar to the male of *H. schizo-*

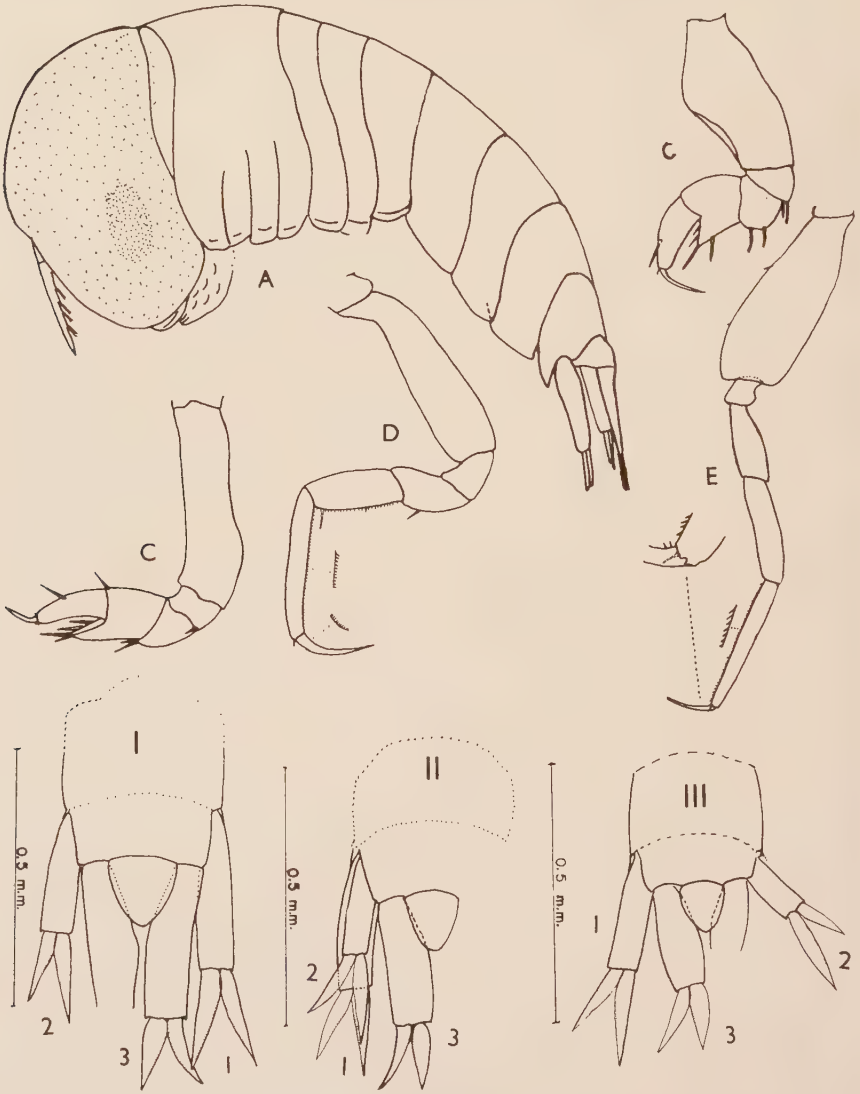

FIGURE 4. *Hyperia (P.) macrophthalma* Vosseler. Female—A. Lateral view of animal; B. p. 1; C. p. 2; D. p. 3; E. p. 5; I, II and III—Development of ups. in different stages.

geneios except for the character differences mentioned in the discussion and shown in Figure 5.

Description of Male. Head one and a half times as high as long, with

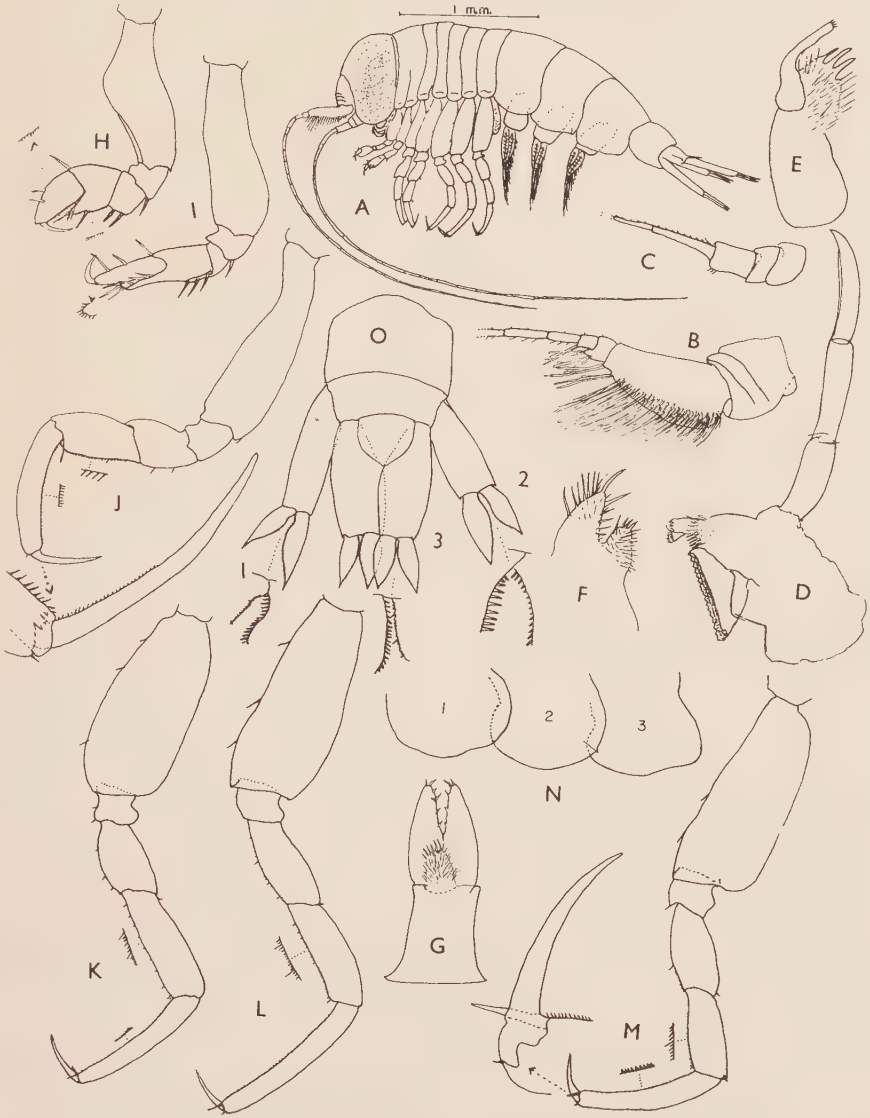

FIGURE 5. *Hyperia (P.) macrophthalma* Vosseler. Male—A. Lateral view of animal; B. ant. 1; C. ant. 2; D. md; E. mx. 1; F. mx. 2; G. maxp; H. p. 1; I. p. 2; J. p. 3; K. p. 5; L. p. 6; M. p. 7; N. Epimera; O. ups.

rounded ventral process not extending to the mouthparts; as long as the first four and one-half pereods together. Pereods 1-2 completely fused, 3-7 free, Somite 7 the longest. Pleon a little longer than pereon. The first epimera rounded and the last two somewhat squared behind. Urosome segments as long as pleod 3.

Ant. 1 inserted well above the middle of the head with about 23 flagellar segments; ventral surface of flagellar segment 1 covered with delicate, long sensory filaments and two pairs of slightly heavier club-shaped filaments, at the distal end; segment 2, also with two pairs of club-shaped filaments, one at distal and the other about the middle of the ventral side of the segment; segment 3 with only one pair of filaments at the distal end; the remaining segments with about three sensory hairs on each ventral side; a few minute hairs on the dorsal surface of the segments.

Ant. 2 inserted on the inferior part of the head; slightly longer than ant. 1; the last segment of the peduncle with a few hairs on the distal ventral end; about 21 flagellum segments with minute hairs on the dorsal surface.

Md. with palp of three equal segments; the outer row of denticulation of the molar process is much stronger than the rest.

Mx. 1 outer plate with three large teeth at tip and the medial margin covered with numerous spinules; palp quite broad when looked at from the side with about four minute spinules at the tip.

Mx. 2 outer plate covered with considerably large spines and three fairly large spines on the apex; the inner plate armed with three or four large spinules on the tip and numerous small spinules on the medial surface.

Maxp. pyriform, with two spines at apex and four on each inner margin of the outer plates.

P. 1 s. 2 as long as s. 3-6 combined; anterior margin dilated at a little above the middle; the dilation is more conspicuous in comparison to that of *H. schizogeneios;* s. 3 with one spine at the postero-distal corner; s. 4 with two spines on the inferior distal margin; s. 5 with a carpal process which reaches almost half way along s. 6, one spine on the serrated posterior medial margin, one spine at the end of the process and two spines on each side, one spine on the antero-distal corner; s. 6 a little longer than s. 5, two spines (usually one) on the anterior margin facing inner side, a posterior margin serrated, finely serrated at the distal end of joint to dactyl; dactyl finely serrated

along the proximal half of the posterior margin, slightly bent.

P. 2 s. 2 about as long as s. 3-6 combined, about three times as long as wide, gradually broadened from proximal to distal; s. 3, one spine at the postero-distal corner; s. 4 processed along the proximal posterior margin of s. 5 forming a somewhat gouge shape with four spines along each side of the antero-distal margin; s. 5 with a long carpal process which extends more than half way of s. 6, gouge shaped, three spines at tip and three spines on each side of gouge margin, one spine at the anterior distal corner; s. 6 armed with two spines (usually one) on the anterior margin, distal end serrated as in p. 1; dactyl, slightly bent, pointed inwards.

P. 3 and 4 are of the same length and shape, a little shorter than p. 5-7. P. 3, s. 2 the anterior margin a little concave along the proximal half (not so much as in p. 4), as long as the three following segments combined, a small spine at the postero-distal corner; s. 3, about as wide as long, not armed; s. 4 shorter than s. 5, two small spines along the postero-medial margin; s. 5, about as long as s. 3 and 4 combined, one spine at postero-distal margin, the postero-distal margin pectinate; s. 6 armed with a minute spinule at antero-distal end, finely pectinate along the posterior margin; dactyl a little more than a half as long as s. 6, with a row of minute hairs along the proximal half of crook.

P. 5-7 alike in form. P. 5, s. 2 about as long as three following segments combined, with three spines on the medial surface of the anterior margin; s. 3 with two spinules, as long as wide; s. 4 with three spinules at the anterior margin, one at the posterior distal corner; s. 5 as long as s. 3-4 combined, with about nine small spinules along the anterior margin, between them finely pectinated; s. 6 one and a quarter times as long as s. 5, anterior margin pectinated, anterior inner-side of distal end prolonged into a minute spine; dactyl about two-fifths as long as s. 6, armed with three or four hairs on the crook. P. 6-7 like P. 5; a spine at the distal end of s. 6 more noticeable than on P. 5, which is a good character of this species, not armed with hairs on the crook of dactyls. (Fig. 5, L-M).

Pleopod. rami usually with eight segments.

Ups. all outer margins of inner rami a little more strongly serrated than the inner margins of the outer rami; up. 1 reaching a little beyond up. 3, peduncle nearly four times as long as wide, one and a half times as long as inner ramus, inner ramus longer than the outer, both opposing margins excavated at the proximal and serrated except for

posterior end; up. 2, about four-fifths as long as up. 1, the peduncle nearly one and a half as long as the inner ramus and a little more than twice as long as wide, inner ramus more stout and larger than the outer, both opposing margins excavated at the proximal and serrated except at the posterior end; up. 3 a little longer than up. 2, peduncle a trifle longer than twice the rami and a little longer than twice the width, wider at middle, the width of both rami somewhat wider than the distal width of the peduncle.

Telson triangular, as wide as long, slightly shorter than half of the peduncle of up. 3, posterior end not so acutely pointed as in *H. schizogeneios.*

Length. 3.2 mm. (Vosseler gives 2 mm of female.)

Distribution. Tropical and subtropical Atlantic, Mediterranean.

Remarks. 1. The numbers of spines on the anterior margin of s. 6 of p. 1-2 may vary from one to two in individual specimens, as in *H. schizogeneios.*

2. The form of the ups. of this male somewhat resembles those of *H. promonotorii* Stebb. (Stebbing, 1888, p. 1385, pl. 166, Fig. B). However, the size range of this male is much smaller than that of *H. promonotorii.*

3. The number of fused pereods is extensive in young stages as in *H. schizogeneios.*

Discussion. 1. In the present study the author has examined 22 females ranging from 1.8 to 3.2 mm. All large sized specimens have well marked pereods (1-4 fused, 5-7 free). The specimens about 2 mm in length agree well with Vosseler's (1901) description and figures. Apparently Vosseler gives the description and figures of a small female specimen of this species from the viewpoint of the proportional length of the inner rami of up. 2. The growth of the inner ramus of up. 2 appears to be negatively allometric to the peduncle and to the outer ramus. The figure 4 (I, II and III) are provided to show the change of up. 2 in different sized animals; I (about 3 mm), II (about 2.7 mm) and III (about 1.8 mm). This also is observed in *H. schizogeneios.*

2. Stephensen (1924, p. 92) synonymized this species with *H. hydrocephala* Vosseler without mentioning the number of fused pereods. He only discriminates between the two by the relative lengths of the last pleod and the first urosome segment. Later Chevreux (1925, p. 404) and Barnard (1930, p. 410-411) placed these two species in the synonymy of *H. latissima* Bov. Then Pirlot (1939) in-

cluded this species in the synonymy of *H. bengalensis* (Giles). According to the number of fused pereods, the female of the species is the same as *H. latissima*. However, the description of the male of *H. latissima* Bov. is dubious (no figure) and Bovallius mentioned that the uropods are like those of the female, therefore he evidently described some kind of young specimen. Secondly, the form and width of the head, and telson do not agree with *H. latissima*. Thirdly, in the present study the author has never confronted the transformed dactyl (Bovallius, 1889, p. 232, P1. XI, Fig. 33) which he mentioned as being "perhaps periodical." For the above reasons, *H. macrophthalma* is a valid species.

3. Male forms other than those of species closely related to *H. schizogeneios* have been dubiously mentioned. Stephensen (1924, loc. cit., p. 88) states "As the male of *H. hydrocephala* is not known, it is perhaps possible that it resembles the male of *H. schizogeneios* so closely as to have been confused with the latter." He synonomized *H. hydrocephala* and *H. macrophthalma* Vosseler. He also lists locality stations for 37 males of *H. hydrocephala* taken by the THOR Expedition, but does not give any character for the male form. Chevereux and Fage (1925, p. 404-405, fig. 403) briefly described *H. latissima* Bov., which included both *H. hydrocephala* and *H. macrophthalma* Voss. and show figures of p. 1 and up. 3 mentioning that the male form resembles that of *H. schizogeneios*.

The male described here is designated as the male of the *H. macrophthalma* for the following reasons:

(a) In agreement with Stephensen's assumption, this male form is the most similar to that of the male of *H. schizogeneios* among the material studied from the SL stations.

(b) In the cast of *H. schizogeneios,* the female has less free somites (1-3 fused, 4-7 free) compared to the male (1-2 slightly fused, 3-7 free). Therefore it is probable that this male should be designated as the male of *H. macrophthalma*.

(c) Another convincing character may be the details of structure of the spine at the distal end of s. 6 or p. 6-7 which have been overlooked by Vosseler. (1901, pl. VI, fig. 24).

(d) From the number of fused pereods, this male is not the male of *H. bengalensis* (Giles) which has all pereods free. Other characters give no identity in the original figures of Giles (1887).

4. Comparison of the character differences of the male of *H. schizo-*

TABLE 1

A Comparison of the Characters of Six Male Specimens of *Hyperia schizogeneios* Stebbing at Various Sizes Showing Ontogenetic Changes

(Fig. 2) Specimen	*Number of pereods Dorsally fused.*	*Length and Form of Antennae.*	*Shape of Uropods*	*Development of Ventral Process of Head*	*Remarks*
A (Adult)	1-2. 3-7 completely free. The suture between 1-2 traced under direct lighting, but not clear.	Both antenna fully developed. Ant. 1 reaches a little beyond up. 3. Ant. 2 far beyond up. 3.	Adult form. Shown in Fig. 1, G.	Ventral process not quite reaching mouthparts.	The appendages of this specimen are shown in Fig. 1, A-G.
B (Juv.)	The same as the above. The suture between 1 and 2 is much more obscure than the above.	Both Ant. 1 and Ant. 2 segmented. The length of Ant. 1=Head+6 pereon segments.	The form more or less like the above. Except that the Telson reaches ½ length of the peduncle of up. 3. All inner rami look a little wider than the outer.	Ventral process of the head almost reaches mouthparts.	
C (Juv.)	1-3. 4-7 completely free. The suture between 2-3 is seen under direct lighting.	Ant. 1 and 2 start to segment. Ant. 1 as long as head+the 1st pereon segment. Ant. 2 somewhat starting to segment.	All ups. and rami are more slender than the above. The length of peduncle =the rami, in up. 3. Up. 2 inner rami a little longer than the outer. Telson length ½ of peduncle of up. 3.	Ventral process almost the same as the above but the posterior margin more extend to the inferior posteriorly.	

TABLE 1—Continued

A Comparison of the Characters of Six Male Specimens of *Hyperia schizogeneios* Stebbing at Various Sizes Showing Ontogenetic Changes

(Fig. 2) Specimen	*Number of pereods Dorsally fused.*	*Length and Form of Antennae.*	*Shape of Uropods*	*Development of Ventral Process of Head*	*Remarks*
D (Juv.)	1-4 completely. 5-7 completely free.	Ant. 1—½ of the head depth. Both non-segmented.	All ups. and rami more slender than the above. The inner rami of up. 2 much longer than the outer. Telson length about the same as above.	Ventral process reaches beyond the mouthparts. The point much sharper than the above.	
E (Juv.)	1-5. 6-7 completely free. The suture of 4-5 slightly seen on the molting cuticle.	The form is the same as the above. Ant. 1, the ventral filaments appear to be fewer than in the above.	Up. 1 and 2, the inner ramus much longer than the outer.	As above, except that it is a little sharper than the above when seen through molting cuticle.	*The illustration omitted due to molting.
F (Juv.)	1-5. 6-7 completely free.	Ant. 1 resembles that of female except for the setae on the anterior margin. Ant. 2 slightly developed.	General form resembles that of the female.	The same as above.	It is hard to determine the sex of this specimen, but the development of Ant. 2 compared favorably with a specimen of this size which I regard as female.

*The molting shell pereods show the trace of sutures of the preceding somites when even the inner animal does not show the sutures clearly.

geneios Stebbing and *H. macrophthalma* Vosseler, as follows:

H. schizogeneios Stebb.	*H. macrophthalma* Voss.
Length 4 mm.	Length 3.2 mm.
Ventral process of head pointed, ribbed, the base under head wide. (Fig. 2)	Rounded, not ribbed, the base not wide. (Fig. 5,A)
A row of small hairs on the dorsal surface of flagellum of ant. 1.	Much smaller and fewer hairs on the dorsal surface of the flagellum.
Usually two spines on the anterior margin of s. 6 of p. 1.	Usually one spine.
Armed with a very small spine at the inner distal end of s. 6 of p. 5-7. (Fig. 1, F)	Armed with a remarkable spine. (Fig. 5,L and M)
General form of ups. slender. (Fig. 1,G)	Stout form. (Fig. 5,O)
Each pair of rami equal in length and form, the posterior tip moderately pointed.	Not equal in shape and length except up. 3, the tip acutely pointed posteriorly. The inner rami noticeably longer than outer in up. 1 and 2.
Up. 3, the length of ramus noticeably longer than the width of peduncle. The length of peduncle nearly three times longer than wide.	The length of ramus equal to the width of peduncle. The length of peduncle a little more than twice that of the peduncle.
Apex of telson slender posteriorly, pointed acutely. Slightly longer than wide.	Telson, convex lateral border, apex not pointed acutely. As long as wide.
First two pereods slightly fused but the previous suture can be seen under right light condition.	First two pereods completely fused.

Hyperia (Parahyperia) atlantica Vosseler, 1901
Figs. 6-7

Hyperia atlantica Vosseler, 1901, p. 67, pl. 6, fig. 5-15.
Hyperia bengalensis (Giles); Shoemaker, 1948, p. 12-13.

Diagnosis. Head about twice as high as long, with rounded ventral process. P. 1, s. 2 with the anterior margin remarkably convex at proximal half of the segment; somewhat oblong; the carpal process of s. 5 extends less than one half way along the finely serrated posterior margin of s. 6; one spine on the anterodistal border of s. 5. P. 3-4, dactyl a little less than half the length of s. 6. P. 5-7 subequal, s. 6 remarkably long in both sexes, length ratio of s. 5 to s. 6 a little less than 3:5, s. 6 armed with hairs on the crook of dactyl (except p. 7 of female), p. 5, s. 2 conspicuously shorter than three following segments combined. *Female,* lateral profile of head slightly globular and confluent with pereon; pereods 1-5 dorsally fused; telson a little shorter than half of up. 3 peduncle. *Male,* lateral profile of the forepart of head

somewhat square; pereods 1-4 dorsally fused. Peduncles of up. 2 and 3 broad, a little longer than twice the width; telson as broad as long, as long as 2/5 of peduncle of up. 3, rounded and not pointed.

Description of Young Female. Length 2.3 mm. Head about twice as

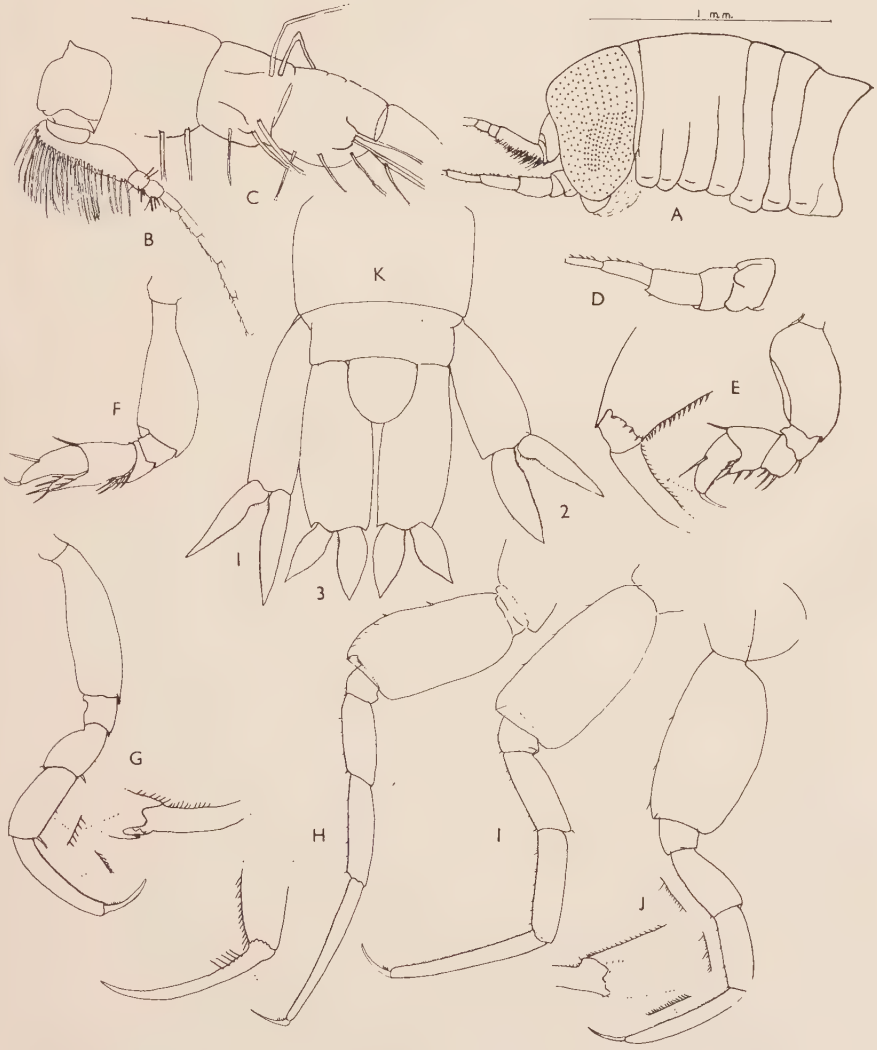

FIGURE 6. *Hyperia (P.) atlantica* Vosseler. Male—A. Lateral view of pereon and head; B. ant. 1; Details of ant. 1; D. ant. 2; E. p. 1; F. p. 2; G. p. 3; H. p. 5; I. p. 6; J. p. 7.

high as long, with rounded ventral process nearly extending to the mouthparts. Pereon a little longer than twice of head length, inflated. Pereods 1-5 completely fused, 6-7 free. Pleod a little shorter than

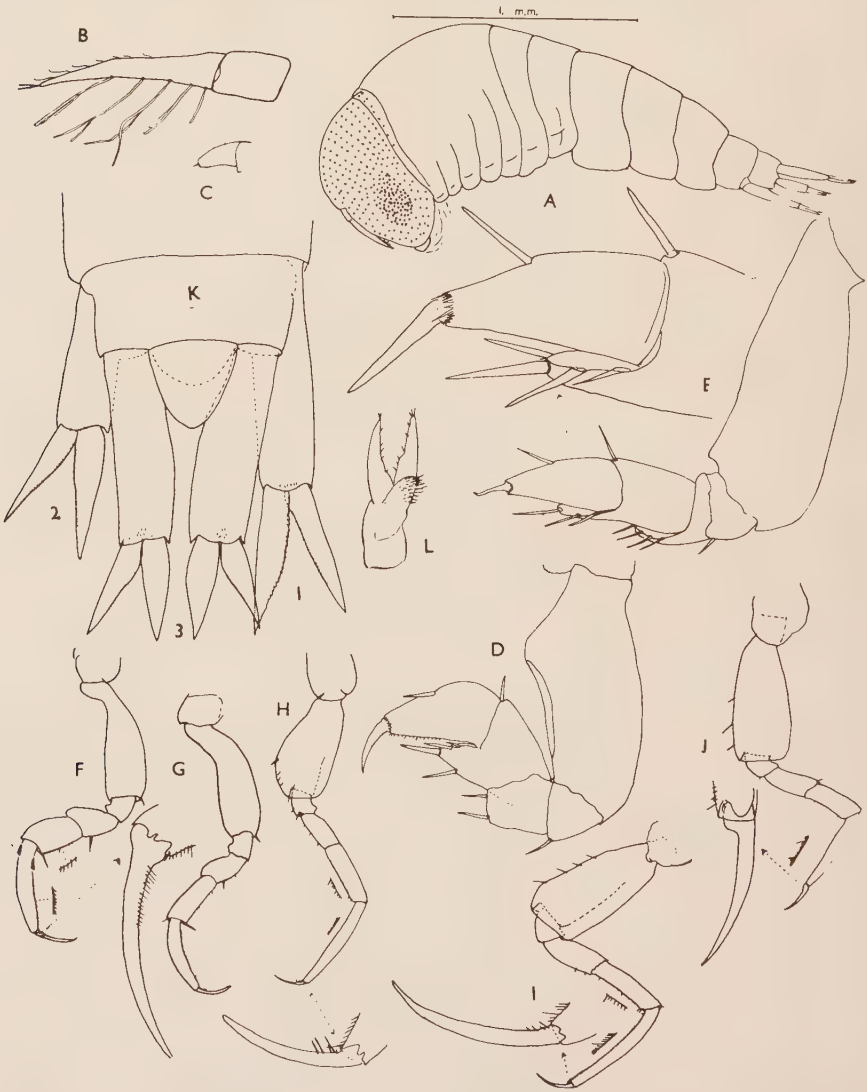

FIGURE 7. *Hyperia (P.) atlantica* Vosseler. Young Female—A. Lateral view of animal; B. ant. 1; C. ant. 2; D. p. 1; E. p. 2; F. p. 3; G. p. 4; H. p. 5; I. p. 6; J. p. 7; ups; L-maxp. F, G, H, I and J are similar magnification.

pereon; the epimerae squared behind. Urosome segment 1 a little shorter than pleod 3.

Ant. 1 inserted slightly above the middle of the head; flagellum about three times as long as the peduncle, with five pairs of sensory filaments on the ventral side, about seven small setae on the dorsal surface, and a pair of small setae at the apex.

Ant. 2 inserted in the lower antennae groove above the ventral process, minute, two or three small hairs on the dorsal surface and a small seta at tip.

Maxp. pyriform, armed with two or three setae at tip, about six setae on each inner margin of the outer plates.

P. 1 s. 2 as long as s. 3-6 combined; anterior margin conspicuously dilated above the middle, as in *H. macrophthalma* Voss. but the dilation is more proximal and more conspicuous; s. 3 armed with one spine at the postero-distal corner; s. 4 with two spines on the interior distal margin; s. 5 with a carpal process which extends almost half way along s. 6, armed with one spine at the antero-distal corner, one spine at the end and two spines on each side of the process; s. 6 longer than s. 5. one spine on the anterior margin, posterior margin finely pectinate distally with a row of small setae, finely serrated at the distal end of the joint with the dactyl; dactyl half as long as s. 6, very finely serrated along the proximal half of the posterior margin.

P. 2 s. 2 a little longer than s. 3-7 combined, gradually broadening distally; s. 3 armed with a spine at the postero-distal corner; s. 4 produced along the proximal posterior margin of s. 5, somewhat in the shape of a gouge with about six spines along the margin; s. 5 with one spine on the antero-distal corner, a carpal process extending half way along s. 6, with one spine at tip and two on each side of the margin; distal end of s. 6 serrated as in p. 1; dactyl curved, half as long as s. 6.

P. 3 and 4 alike in form and length. S. 2 as long as three following segments combined, one spine at the postero-distal corner; s. 3, unarmed, s. 4 a little shorter than s. 5, armed with a spine on the posterior margin; s. 5, armed with a spine at the postero-distal end, posterior margin pectinated; s. 6 posterior margin finely pectinated; dactyl slightly less than half as long as s. 6, with a row of minute hairs along the proximal part of crook.

P. 5-7 similar in form and length. P. 5, s. 2 a little shorter than three following segments combined, anterior distal border of s. 2 a little dilated which differs from that of p. 6 and 7, one spine on the anterior

surface margin and below this a few minute setae which can be detected under high magnification, and it resembles Vosseler's figure of the male (1901, pl. 6, fig. 14) except for a spine; s. 3 about as long as wide and armed with two small spinules on the anterior margin; s. 4 about one and a half times as long as s. 3, armed with three small spinules on the anterior margin; s. 5 anterior margin pectinated; s. 6 nearly as long as the two preceding segments combined, the length-ratio of s. 6 to s. 5 almost 3:2, anterior margin finely pectinated; dactyl one-third as long as s. 6, a row of three or four spinules on the proximal anterior margin. P. 6 like p. 5 but four spines on the anterior border of s. 2. P. 7 with three spines on the anterior border of s. 2, dactyl unarmed. The ratio of s. 6 to s. 5 in p. 6-7 nearly 2:1.

Pleopod rami usually with eight segments.

Ups. all the inner rami a little stouter and longer than the outer. Up. 1 extending to the posterior end of up. 3, peduncle about four times as long as wide, about one and a half times as long as inner ramus, inner ramus longer than the outer, the opposing margins serrated, the outer margin of inner ramus more strongly serrated than the inner margin of the outer ramus; up. 2, three-fourths as long as up. 1, peduncle three times as long as wide and a little longer than the inner ramus, opposing margin serrated; up. 3 slightly longer than up. 2, peduncle a little longer than three times the width, nearly twice as long as ramus, the inner medial margin of outer ramus slightly serrated.

Telson triangular with convex lateral borders, as long as wide, wider than peduncle of up. 3, a little less than half as long as peduncle of up. 3.

Length. 3.5 mm (male). Vosseler gives 4.0 mm.

Distribution. Vosseler gives one specimen each from South Equatorial Current, Rio Tocant and Gulfstream. This is the first record since Vosseler.

Remarks. The male figures agree closely with Vosseler's description and figures of *H. atlantica* except for the following minor points:

1. Ant. 1, first segment of flagellum a little more slender, and a raised small protruberance on the third flagellar segment instead of the second.

2. P. 5-7, with spines on the anterior border of s. 2; p. 5, s. 2 is relatively shorter than in p. 6 and 7. Vosseler gives no figures of p. 6 and 7 but only a brief description.

Discussion. Outside of the above differences in *Remarks,* this specimen

agrees well enough with the other characters. The identity of this specimen is much closer to *H. atlantica* than *H. latissima* Bov. for the reasons which the writer mentioned in the discussion of *H. macrophthalma* Voss.

No females with eggs or juveniles were found in the SL station materials. Although the pereon of this figured and described specimen is much inflated, evidently the specimen is not fully matured due to its size of 2.3 mm. This female is closely related to *H. hydrocephala* Voss in the light of the number of fused pereods. However, the following character differences will suffice for the differentiation: (1) s. 2 of p. 5-7 is not narrow proximally. (2) hairy armature on the crook of dactyl of p. 5 and 6. (3) the round and short telson.

The author's identification of this female specimen as the female of *H. atlantica* Voss. is based on the following reasons:

1. As observed in the closely related species, *H. schizogeneios* Stebbing and *H. macrophthalma* Voss, the number of fused pereods is always greater in the female.

2. The dilation of the anterior margin of s. 2 of p. 1 greatly resembles Vosseler's figures of *H. atlantica.*

3. The most convincing and similar character is the structure of p. 5, especially of s. 2 and the dactyl.

Hyperia (Parahyperia) fabrei (Milne-Edwards, 1830)
Fig. 8

Lestrigonus Fabrei Milne-Edwards, 1830, p. 392.
Hyperia Fabrei Bovallius, 1889, p. 206, pl. 10, figs. 40-53; Vosseler, 1901, p. 58, pl. 5, figs. 5-15; Stephensen, 1924, p. 83; Spendl, 1924, p. 22-23; Barnard, 1930, p. 410; Pirlot, 1939, p. 34; Hurley, 1955, p. 137; Bowman, 1953, p. 247, fig. 30-32.

Diagnosis. Head very much deeper than long, with a minute rounded ventral process. Pereods 1-2 fused. Anterior margin of s. 2 of p. 1 evenly rounded. S. 5 of p. 3 and 4 with long spines on the posterior margin. S. 5 of p. 5-7 without long spines; s. 2 of p. 5-7 considerably more than half as broad as long; s. 2 of p. 5 the broadest. Outer plates of maxp. pyriform, pointed distally, densely setose on the tips and inner margins. *Male,* head a little less than twice as deep as long; as long as the first five pereods combined. Ant. 1 as long as head, pereods and pleods combined. Ant. 2 a little longer than Ant. 1. Opposing margins of rami of ups. serrated; excavated proximally. Telson not reaching ½ the length of the peduncle of up. 3. *Female,* head about 2.5 times deeper than long; about as long as the first four and a half

pereods together. Ant. 1 inserted a little below the middle of the head; reaches a little beyond the ventral border of the head; tapering towards the end. Ant. 2 very small, conical, hidden in the antennal groove.

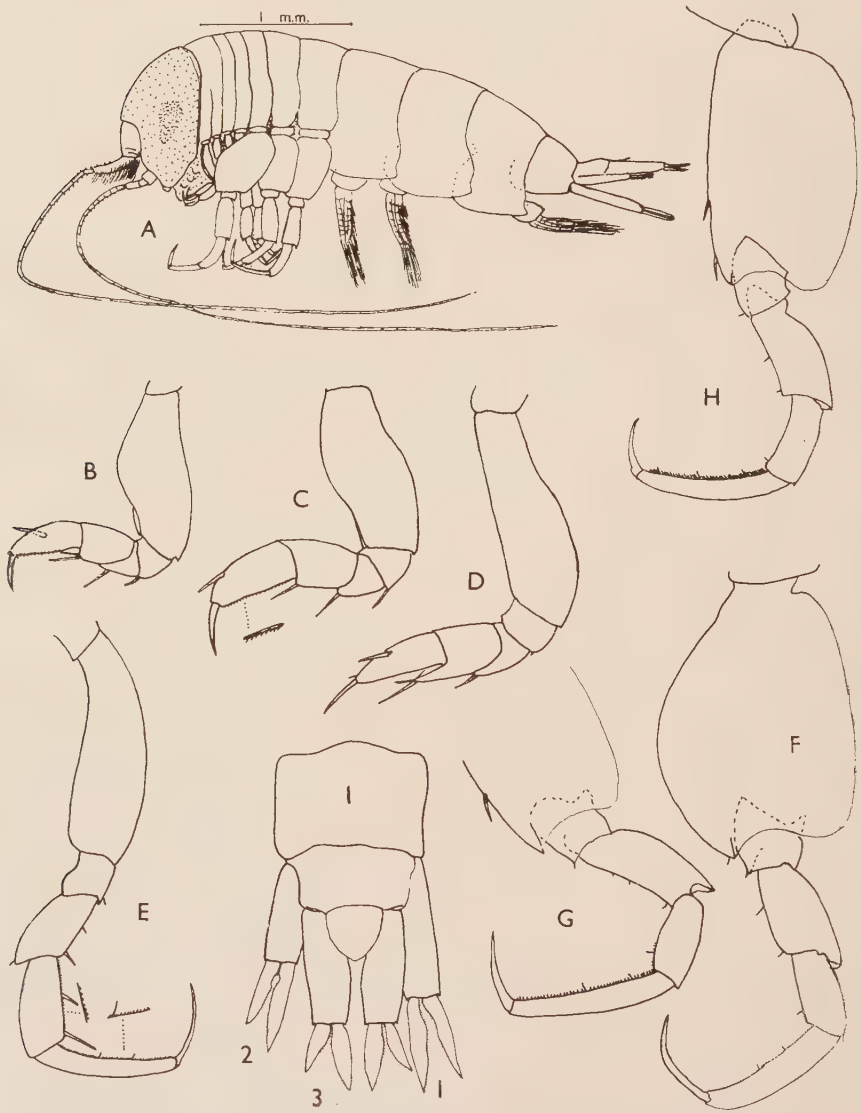

FIGURE 8. *Hyperia (P.) fabrei* (M. Edw.). Male except (B)—A. Lateral view of animal; B. p. 1 of female; C. p. 1; D. p. 2; E. p. 4; F. p. 5; G. p. 6; H. p. 7.

Opposing margins of ups. of the rami serrated.

Length. Male 4 mm, female 3 mm. (Bovallius, 1889, gives length 4-6 mm).

Distribution. Atlantic (41°N.-15°S.), Red Sea, Indian Ocean, Mediterreanean, Pacific.

Remarks. Both males and females agree with the description and figures of Bovallius (1889), and Vosseler (1901) except for the following points:

1. In some female specimens the dorsal part of the pereods are more inflated than in Vosseler's figure. This seems to be a post-spawning character, since no eggs or juveniles were found.

2. The spine at the posterior distal corner of s. 5 of p. 1 is much longer than in Vosseler's figure (pl. 5, fig. 9).

3. Bovallius (1889, p. 210, pl. 10, fig. 44) describes and illustrates a spine on the middle of the posterior margin of s. 5 of p. 1 of the male, but there is no such spine on my specimen.

4. There is a little difference in the shape and length of the telson. Bovallius described and figures it as shorter and semicircular. In the specimen figured here, it is semi-triangular and slightly less than half of the peduncle of up. 3 and is similar to that of Vosseler's female.

Hyperia (Parahyperia) macrodactyla Stephensen, 1924

Fig. 9

Hyperia macrodactyla Stephensen, 1924, p. 90-91, fig. 35.

Diagnosis. Pereods 1-3 fused. Ventral process of the head small, with a minute point. S. 2 of p. 1 strongly dilated; more or less semicircular in form. Dactyl of p. 3-7 remarkably long and curved. P. 5 very short; its length is only 2/3-3/4 of p. 3-7. S. 4-6 of p. 3-7 with large spines. Inner ramus of male up. 3, shorter than the outer ramus.

Description of Female. Head large, twice as high as long, about as long as the first three fused pereods together. Head with very small ventral process. Pereods 1-3 fused, 4-7 free, 4-6 subequal in length, 7 is a little longer. Pleod a little shorter than pereon, the first two epimera rounded and the last squared behind. Urosome a little shorter than pleon segment 3.

Ant. 1 inserted well below the middle of the head. Flagellum about 3.5 times as long as peduncle, with five pairs of sensory filaments on the ventral side, five short setae on the upper surface. Three small hairs on the apex. Peduncle covered with very fine hairs.

Ant. 2 inserted in the inferior part of head, with one setae on the ventral side and two hairs on the tip.

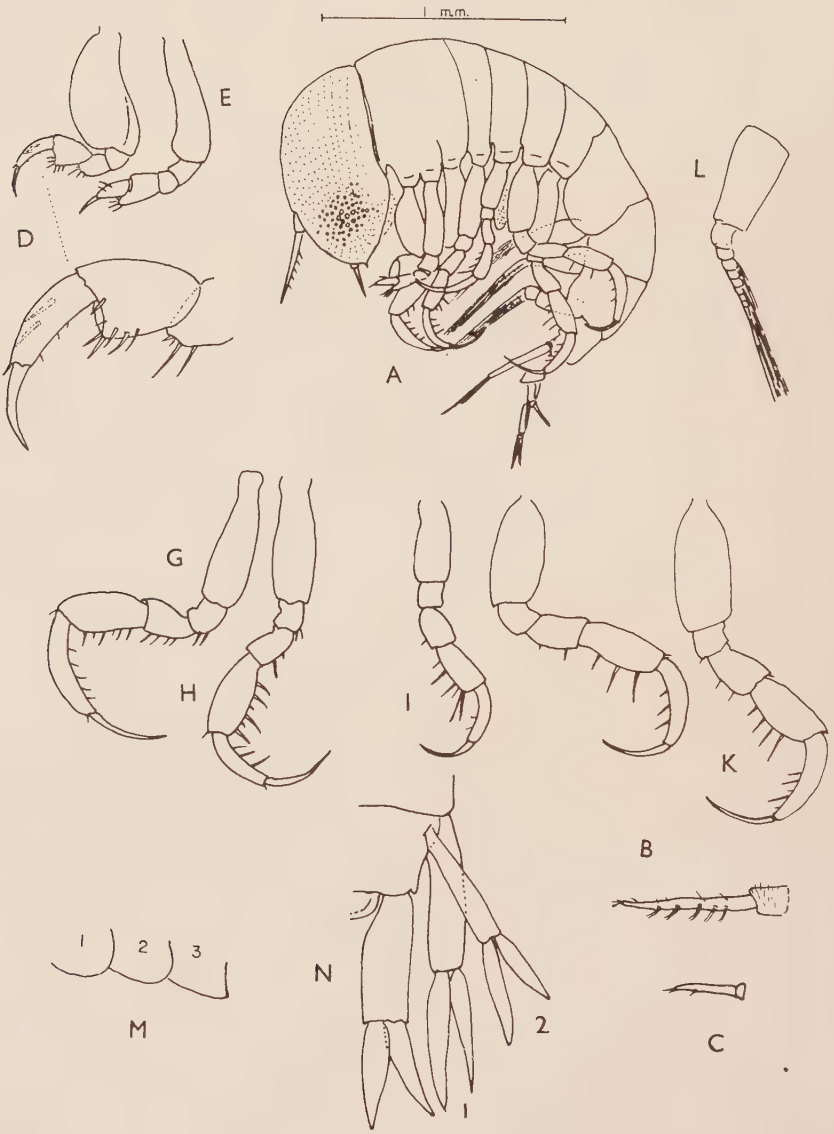

FIGURE 9. *Hyperia (P.) macrodactyla* Stephensen. Female—A. Lateral view of animal; B. ant. 1; C. ant. 2; D. p. 1; E. p. 2; G. p. 3; H. p. 4; I. p. 5; J. p. 6; K. p. 7; L. Pleopod 2; M. Epimera; N. ups.

P. 1. s. 2 strongly dilated, about as long as the four following segments combined, narrow at the proximal base; s. 4 longer than s. 3, with two long and two short spines on the postero-distal margin; s. 5 abruptly cut off distally, carpal process not developed, with two spines on the posterior distal corner and three spines on the posterior margin; s. 6 one-half as wide as s. 5, with two spines on inner anterior margin; dactyl curved and slightly shorter than s. 6.

P. 2. s. 2 much more slender than p. 1, as long as four following segments combined, somewhat broadened distally; s. 5 with a small carpal process with four spines at the posterior distal corner; s. 6 with two spines on the middle of the anterior margin; dactyl as in p. 1.

P. 3 and 4. are of the same length, somewhat longer than p. 6 and 7. P. 3, s. 2 slightly narrowed proximally, a little shorter than three following segments combined; s. 3 with 2 spines on the postero-distal margin; s. 4 with four spines on the posterior margin; s. 5 with four spines on the posterior margin and two spinules between them, a little longer than the two preceding segments combined; s. 6 a little longer than s. 5, with five spines on the posterior margin and one spinule at the antero-distal corner; dactyl as long as s. 6 and curved. P. 4 like p. 3, except for three spines on the posterior margin of s. 4, three spines on s. 6.

P. 5. considerably shorter (about ¼) than p. 3, 4, 6, or 7 (the length is a good character of this species); s. 2 as long as s. 3, 4 and ½ of 5 together; s. 4 with only one spine on the anterior margin; s. 5 two spines and two spinules on the anterior margin, two spines at the anterior distal corner; dactyl a little longer than s. 6, considerably curved.

P. 6 and 7, s. 2 a little heavier and broader than that of p. 3-4. P. 6, s. 4 with two spines on the anterior margin; s. 5 and 6 each with three spines on their anterior margins, s. 5 with a spinule at the posterior distal corner. P. 7 like p. 6, except for four spines on the anterior margin of s. 5.

Pleopods, rami with 8 segments and the filaments rather long.

Uropods, inner rami longer than outer; No rami are serrated or excavated; up. 1 reaches nearly to apex of up. 3, peduncle a litte longer than the rami; up. 2 a little shorter than up. 1, the peduncle is more slender than that of up. 1 or 3; peduncle of up. 3 broader than others, the inner ramus somewhat broader than the outer.

Telson, semicircular, about 1/5 of up. 3 peduncle.

Length. 2.8 mm.

Distribution. Mediterreanean.

No one has reported this species since Stephensen's (1924) original description. On the THOR expedition he found 34 specimens (33 males, 1 female) on the surface. One female specimen described here is from SL 40, B-2 (Depth 109 m, Time 00:45) near the surface. The other (1.5 mm) is from SL 41, B-6 (Depth 274 m, Time 00:28).

Remarks. The female specimen described here agrees very closely with Stephensen's figure and description (1924, p. 90-91, Fig. 35) of the male. This female carries eggs and a few very early stages of young, therefore there is no doubt that this female is a mature adult. Comparing this female to Stephensen's figures of the male, the following sexual differences are seen:

1. The female head is about as long as the first three fused pereods while the male head is about as long as the first four pereods combined.

2. The female has two spines on the anterior margins of s. 6 of p. 1 and p. 2 whereas there is one spine each on the male figures as described by Stephensen.

3. The inner ramus of up. 1 has no excavation at its base in the female, but a small excavation is present in the male. The inner ramus of up. 3 is longer than the outer in the female, but shorter in the male.

Ant. 1 and especially ant. 2 of the female of this species are well developed and fairly longer than in the female of any other species of *Parahyperia.*

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STUDIES ON HELMINTH PARASITES FROM THE COAST OF FLORIDA. II. DIGENETIC TREMATODES FROM SHORE BIRDS OF THE WEST COAST OF FLORIDA. 1[1]

ROBERT F. HUTTON AND FRANKLIN SOGANDARES-BERNAL
Florida State Board of Conservation Marine Laboratory [2]
Maritime Base, Bayboro Harbor, St. Petersburg, Florida

ABSTRACT

Ten digenetic trematodes are reported from shore birds captured in the Tampa Bay and Boca Grande areas. New locality records are given for nine species of trematodes. New host records are given for six species of trematodes. Notes are given on stages in the life cycles of *Mesostephanus appendiculatoides*, *Phagicola longa* and *Parascocotyle diminuta*.

INTRODUCTION

The trematodes reported herein were collected from shore birds captured by the authors in the Tampa Bay and Boca Grande areas along the west coast of Florida. This publication is a continuation of a series of studies on the diseases and parasites of marine and coastal animals. These studies are currently a major part of the Florida State Board of Conservation research program. All locality records for trematodes reported in this paper are considered to be new.

Feeding experiments with laboratory-raised animals have shown that the metacercarial stage of *Mesostephanus appendiculatoides* (Price, 1934) Lutz, 1935, and *Phagicola longa* (Ransom, 1920) Price, 1932, occur in the striped mullet, *Mugil cephalus* L., the fantail mullet, *M. trichodon* Poey, and the white mullet, *M. curema* Cuvier and Valenciennes. These experiments will be discussed more fully elsewhere. The brown pelican, *Pelecanus occidentalis carolinensis* Gmelin, has been found to be a natural definitive host for *Mesostephanus appendiculatoides* (Fig. 1c) and *Phagicola longa*, while the American egret, *Casmerodius albus egretta* (Gmelin), has been found to be a natural definitive host for *Phagicola longa* (Fig. 1b). *Cerithium muscarum* Say harbors a cyathocotylid cercaria that develops from elongate sporocysts. This cercaria is suspected to be the larva of *Mesostephanus appendiculatoides*.

All figures have been drawn with the aid of a camera lucida from

[1]This investigation was supported in part by research grant E-1447(C2) from the National Institutes of Health, U. S. Public Health Service.
[2]Contribution No. 25.

specimens killed in hot water, transferred immediately to FAA (formalin-acetic acid-alcohol), and mounted in Canada balsam, with the exception of *Pachytrema sanguineum, Clinostomum attenuatum Cryptocotyle lingua, Galactosomum cochlear,* and *Stephanoprora denticulata,* which were flattened under a glass plate and killed with FAA before mounting. Where possible representative specimens of trematodes reported in this paper were deposited in the U. S. National Museum Helminth Collection. Unless otherwise stated all measurements cited in this paper are in microns.

Acknowledgments are extended to Allen McIntosh, Parasitologist, Animal Disease and Parasite Research Branch, U. S. Department of Agriculture, for loan of material from the U. S. National Museum Helminthological Collection, and Stephen Prudhoe, Department of Zoology, British Museum (Natural History), London, for loan of a slide of *G. fregatae.*

Family Clinostomatidae Luhe, 1901

1. *Clinostomum attenuatum* Cort, 1913

Fig. 1a

HOST: *Phalacrocorax auritus floridanus* (Audubon), Florida cormorant, new host record.
INCIDENCE OF INFECTION: 1 of 4 specimens.
NUMBER: 7.
LOCATION: Trachea.
LOCALITY: Bayboro Harbor, Tampa Bay, Florida, new locality record.
DATE: April 6, 1958.
U. S. NAT. MUS. HELM. COLL. NO.: 56267.

Discussion. This species keys out to *Clinostomum attenuatum* Cort in the key presented by Price (1938). Baer (1933) reporting on *C. attenuatum* states: "La métacercaire a été trouvée par Osborn (1911 et 1912) dans la musculature et dans la cavité générale des Grenouilles *Rana catesbiana* Shaw et *Rana halecina* Kalm = *R. pipens* Gm. . . ." Also: "Adulte chez *Botaurus lentiginosus* (Mont.) et *Florida caerulea* (L.)." Price (1937) reported a single specimen of *Clinostomum attenuatum* from the trachea of a chicken. Manter (1937) identified "beyond all doubt" an immature specimen of *C. attenuatum* from the intestine of a pigeon.

In our specimens the cuticle appeared to be devoid of spines except for several rows around the oral sucker. The testes are typically

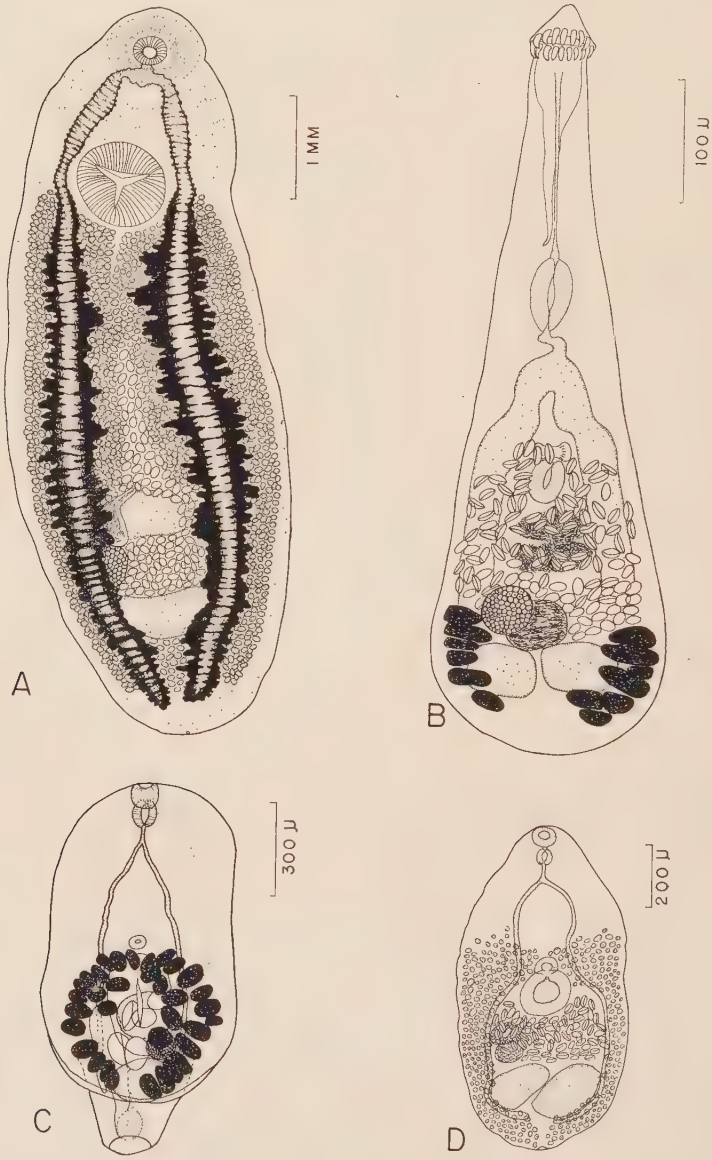

FIGURE 1. All figures were drawn with the aid of a camera lucida. A, *Clinostomum attenuatum,* ventral view of whole mount from cormorant. B, *Phagicola longa,* ventral view of whole mount from pelican. C, *Mesostephanus appendiculatoides,* ventral view of whole mount from pelican. *D, Cryptocotyle lingua,* ventral view of whole mount from herring gull.

TABLE 1

MEASUREMENTS OF 7 SPECIMENS OF *Clinostomum attenuatum* FROM THE CORMORANT.

	1	2	3	4	5	6	7
Body Length	7358	7098	6900	7098	6500	7300	7150
Maximum Body Width	2522	2080	2650	2392	2496	2370	2496
Diameter of Oral Sucker	310	310	380	328	354	328	310
Diameter of Ventral Sucker	855	828	864	820	837	790	820
Ovary	282 x 465	—	291 x 346	—	291 x 428	273 x 400	300 x 428
Anterior Testis	500 x 900	—	—	—	—	436 x 1000	500 x 1000
Posterior Testis	400 x 865	—	—	455 x 774	436 x 930	455 x 920	518 x 980
Ovum	68 x 112	71 x 112	65 x 109	69 x 109	73 x 109	71 x 112	71 x 115

crescent-shaped as shown in Fig. 1a; however, a few are somewhat lobed. Measurements obtained from our 7 specimens are shown in Table 1.

Family HETEROPHYIDAE Odhner, 1914

2. *Phagicola longa* (Ransom, 1920) Price, 1932

Fig. 1b

HOSTS: *Pelecanus occidentalis carolinensis* Gmelin, brown pelican; *Casmerodius albus egretta* (Gmelin), American egret, new host record; *Mugil cephalus* L., striped or black mullet, second intermediate host; *M. curema* Valenciennes, white or silver mullet, new second intermediate host record; *M. trichodon* Poey, fantail mullet, new second intermediate host record.

INCIDENCE OF INFECTIONS: Pelican 1 of 4; egret 8 of 12.

NUMBERS: Pelican 13; egret 1, 1, 1, 2, 4, 5, 5, 7.

LOCATION: Mostly in anterior 1/3 intestine.

LOCALITIES: Pelican — Gasparilla Sound, Charlotte Harbor, Florida, new locality record; egret — Boca Ciega Bay, Florida, new locality record.

DATES: Pelican — June 19, 1958; egret — April 29, May 8, 9, 19, 19, 21, 26, June 3, 1958.

U. S. NAT. MUS. HELM. COLL. NO.: 39004.

Discussion. Ransom (1920) described *Ascocotyle longa* from the Alaskan fox, *Vulpes lagopus*. Witenberg (1929) raised the subgenus *Parascocotyle* Stunkard and Haviland, 1924, to generic rank and included *Ascocotyle longa* in this genus. Price (1932) regarded *Phagicola* Faust, 1920, and *Parascocotyle* synonymous. Hutton and Sogandares (1958) considered *Ascocotyle* Looss, 1899, *Parascocotyle* Stunkard and Haviland, 1924, and *Phagicola* Faust, 1920, as valid genera and presented a key for separating them. The species reported here was retained in the genus *Phagicola*. Witenberg (1929) recorded *Parascocotyle longa* from Palestinian dogs and cats and in a jar labelled "*Cotylogonimus persicus* from the Persian wolf (No. 3935)." *Mugil cephalus, M. capito, Lichia amia,* and *Barbus canis* were listed as secondary hosts in Palestine by Witenberg (*loc. cit.*). Price (1935) states: ". . . the writer regards the forms described by Ransom from the United States, by Witenberg from Palestine, and by Ciurea from Roumania as representing a single species." Dawes (1956) lists the dog, cat, fox and black kite as hosts for *Phagicola longa*. Hutton (1957) identified *P. longa* from white rats, opossums, cats and raccoons which had been fed mullet (*Mugil cephalus* and *M. curema*) from Florida

waters. Metacercariae of *P. longa* were found in the fish hearts. The specimen shown in Figure 1b was from a naturally infected American egret. The following measurements were made from living specimen taken from the intestine of a opossum and placed under slight cover glass pressure: body length 630-720, maximum body width 252-270, diameter of oral sucker 40-44, pharynx width 42-50, diameter of ventral sucker 52, ovum 18 x 10. Figure 1b does not show the cuticular spines. These spines cover the body with the exception of a narrow postoral zone and the extreme posterior end of the body.

3. *Parascocotyle diminuta* (Stunkard and Haviland, 1924) Hutton and Sogandares-Bernal, 1958
Fig. 2c

HOSTS: *Phalacrocorax auritus floridanus* (Audub.), Florida cormorant, new host record; *Hydranassa tricolor ruficollis* (Gosse), Louisiana heron, (immature), new host record; *Fundulus similis* (Baird and Girard), Gulf killifish, second intermediate host, new host record.

INCIDENCE OF INFECTIONS: Cormorant 1 of 6; heron 1 of 2.

NUMBERS: Hundreds.

LOCATIONS: Mostly in anterior 2/3 of intestine.

LOCALITIES: Cormorant—Bayboro Harbor, Tampa Bay, Florida, new locality record; heron—Tarpon Key, Boca Ciega Bay, Florida, new locality record.

DATES: Cormorant—April 6, 1958; heron, May 23, 1958.

Discussion. Ascocotyle (Parascocotyle) diminuta was described by Stunkard and Haviland (1924) from the rat. Stunkard and Uzman (1955) redescribed the species under the name *Ascocotyle (Phagicola) diminuta.* They reported the common killifish, *Fundulus heteroclitus,* and the striped killifish, *F. majalis,* as second intermediate hosts. We found the larva of this species in the gills of *F. similis* (Baird and Girard) from Tampa Bay, Florida. Specimens of *Parascocotyle diminuta* were obtained from the intestine of laboratory-raised hamsters after feeding them the gills of *F. similis.* The following measurements were made from a specimen of *P. diminuta* taken from the cormorant, killed in hot water and mounted in Canada balsam: body length 418, maximum body width 172, diameter of oral sucker 38, pharynx diameter 26, diameter of ventral sucker 40, ovum 18 x 10. As in the case of *Phagicola longa* the cuticula of *Parascocotyle diminuta* is covered with spines except for a narrow postoral zone and the extreme posterior end of the body. Figure 7 does not show these spines.

4. *Cryptocotyle lingua* (Creplin, 1825) Fischoeder, 1903
Fig. 1d

HOST: *Larus argentatus smithsonianus* Coues., herring gull.
INCIDENCE OF INFECTION: 1 of 1 specimen.
NUMBER: 3.
LOCATION: Anterior 1/3 intestine.
LOCALITY: 2 miles east of Albert Whitted Airport, St. Petersburg, Tampa Bay, Florida, new locality record.
DATE: October 11, 1958.

Discussion. This species has been reported numerous times from birds and mammals in Europe, North America and Japan. Stunkard and Willey (1929) and Stunkard (1930) have reported on the life history of this species.

5. *Galactosomum cochleariforme* (Rudolphi, 1819) Pratt, 1911
Fig.2b

HOST: *Fregata magnificens rothschildi* Mathews, man-of-war bird.
INCIDENCE OF INFECTION: 1 of 2 specimens.
NUMBER: 22.
LOCATION: Intestine.
LOCALITY: Gasparilla Sound, Charlotte Harbor, Florida, new locality record.
DATE: June 20, 1958.

Discussion. Galactosomum cochleariforme has been reported by Pratt (1911), Linton (1928), and Manter (1930) in the man-of-war bird from Dry Tortugas, Florida. We found 22 specimens of this worm in the intestine of 1 of 2 birds from Charlotte Harbor, Florida. In general our specimens agree with Pratt's (1911) description of *G. cochleariforme*. Prudhoe (1949) gives a key to the species of *Galactosomum*. According to this key *G. cochleariforme* has vitelline follicles arranged in a number of rosette-like clusters and a pharynx as large as the oral sucker. Neither of these characteristics appear to be true in our 8 specimens or in 2 specimens collected by Dr. Harold Manter, U. of Nebraska, and examined by us. The latter two specimens were identified by Dr. Manter as *G. cochleariforme*. In the aforementioned specimens the vitelline follicles are more or less evenly dispersed along the sides of the body as shown in Figure 2b. This condition may have been produced by the method of fixing and mounting the specimens. Also, the pharynx is approximately one-half the size of the oral sucker. The anterior part of the body of our specimens is covered with minute

spines and the uterus is packed full of eggs (neither the body spines nor the eggs are shown in Fig. 2b).

Recently, Dollfus and Capron (1958) stated: "Mélangés à ces *Pygidiopsis,* il y a environ une dizaine de *Galactosomum cochlear* (Diesing, 1850), espèce connue chez d'autres espèces de *Sterna.* F. N. Morosov (in Skrjabin, 1952, p. 416) a eu grand tort de reunir cette espece a *G. cochleareforme* (Rudolphi, 1819), espèce bien distincte, comme l'a rappelé St. Prudhoe (1950, p. 143-145)."

6. *Galactosomum* sp.
Fig. 2f

HOST: *Larus atricilla* Linnaeus, laughing gull, new host record.
INCIDENCE OF INFECTION: 1 of 8 specimens.
NUMBER: Not counted.
LOCATION: Rectum.
LOCALITY: 2 miles east of Albert Whitted Airport, St. Petersburg, Tampa Bay, Florida.
DATE: October 11, 1958.

Discussion. We have compared our specimens of *Galactosomum* from the laughing gull with (1) a slide of *G. fregatae* Prudhoe, (2) a specimen identified by R. M. Cable as *G. cochlear* (Diesing) and deposited in the U. S. National Museum Helminthological Collection (No. 38213), (3) specimens of *Galactosomum* collected by us from the herring gull, *Larus argentatus smithsonianus* Coues., the brown pelican, *Pelecanus occidentalis carolinensis* Gmelin, and the frigate-bird, *Fregata magnificens rothschildi* Mathews, and (4) a specimen in our collection identified as *G. puffini* Yamaguti, 1941, from the brown pelican, *Pelecanus occidentalis californicus* Ridgway, in the Gulf of Panama. Prudhoe (1949) described *Galactosomum fregatae* from specimens "not in very good condition" taken from two frigate-birds, *Fregata magnificens rothschildi,* collected in Trinidad, West Indies. Prudhoe states: "This species rather closely resembles *G. cochlear* (Diesing), but differs principally in the greater anterior extent of the vitelline follicles, and to a lesser degree in the shape and smaller size of the body, the greater relative length of the prepharynx and the shape of the seminal vesicle." Chandler (1951) emended the original description of *G. fregatae* from specimens taken from a man-o-war bird (frigate bird) collected on the coast of the Gulf of Mexico near Corpus Christi, Texas. He compared *G. fregatae* with *G. cochlear* stating ". . ., and the seminal receptacle is described as being long and coiled. The

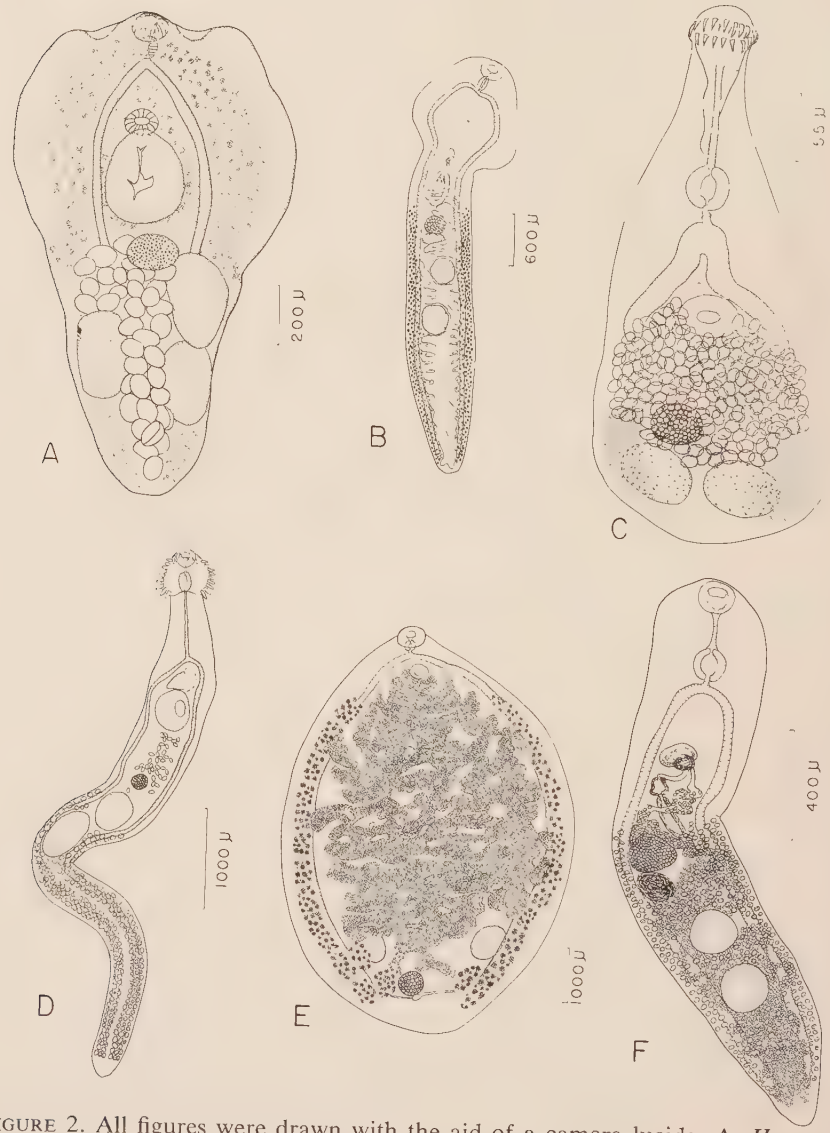

FIGURE 2. All figures were drawn with the aid of a camera lucida. A, *Hysteromorpha triloba*, ventral view of whole mount from cormorant. B, *Galactosomum cochleariforme*, ventral view of whole mount from man-o-war bird. C, *Parascocotyle diminuta*, ventral view of whole mount from cormorant. D, *Stephanoprora denticulata*, ventral view of whole mount from herring gull. E, *Pachytrema sanguineum*, ventral view of whole mount from laughing gull. F, *Galactosomum* sp., ventral view of whole mount from laughing gull.

last, if correct, appears to be the only definite character separating these two species." Chandler (page 186) was obviously referring to the seminal vesicle and not the seminal receptacle.

Our specimens from the *Larus atricilla* L. resemble *Galactosomum fregatae* in some respects and *G. cochlear* in others. Living specimens of flukes taken by us from the laughing gull revealed the seminal vesicle to be long and coiled and later after movement the same vesicle appeared without spiral turns. Thus *G. cochlear* and *G. fregatae* may be synonymous, but we feel that a more critical study of our material from the hosts listed above is necessary before we can identify these specimens with any degree of certainty.

The anterior part of the body of our specimens is covered with minute spines (not shown in Fig. 2f).

Family CYATHOCOTYLIDAE Poche, 1925

7. *Mesostephanus appendiculatoides* (Price, 1934) Lutz, 1935

Fig. 1c

HOST: *Pelecanus occidentalis carolinensis* Gmelin, (Eastern) brown pelican, new host (subspecies) record; *Mugil cephalus* L., black or striped mullet, new second intermediate host; *M. curema* Valenciennes, white or silver mullet, new second intermediate host; *M. trichodon* Poey, fantail mullet, new second intermediate host.

INCIDENCE OF INFECTION: In 3 of 3 specimens of definitive host.

NUMBERS: 35, hundreds, 7 (immature).

LOCATION: Mainly in anterior 2/3 intestine.

LOCALITIES: Boca Ciega Bay, Florida; Gasparilla Sound, Charlotte Harbor, Florida; new locality records.

DATES: May 9, 1958; May 28, 1958; June 19, 1958.

U. S. NAT. MUS. HELM. COLL. NO.: 56241.

Discussion. Price (1934) described the above species as *Prohemistomum appendiculatoides* from the small intestine of *Pelecanus occidentalis occidentalis* collected at Levantade Keys, Samana Bay, Dominican Republic. The present report indicates two new locality records and extends the known geographical range to include the west coast of Florida. Cysts fed to laboratory-raised opossums, *Didelphis virginianus,* and one of two laboratory-raised Black Crowned Night Herons, *Nycticorax nycticorax hoactli* (Gmelin), developed in the intestine into adult worms easily recognized as *M. appendiculatoides* (Price, 1934). We believe the first intermediate host of this species is *Cerithium muscarum* Say. *Cerithidea costata turrita* Stearns harbors a

similar cyathocotylid cercaria which may be the same species as the one occurring in *Cerithium muscarum*.

Family DIPLOSTOMATIDAE Poirier, 1886

8. *Hysteromorpha triloba* (Rudolphi, 1819) Lutz, 1931

Fig. 2a

HOST: *Phalacrocorax auritus floridanus* (Audub.), Florida cormorant, new host (subspecies) record.
INCIDENCE OF INFECTION: In 1 of 6 specimens.
NUMBER: Hundreds.
LOCATION: Entire length of intestine.
LOCALITY: Bayboro Harbor, Tampa Bay, Florida, new locality record.
DATE: April 6, 1958.
U. S. NAT. MUS. HELM. COLL. NO.: 56240.

Discussion. Several hundred specimens of this parasite were removed from the intestine of a single cormorant. The bird, apparently sick, was captured with a dipnet while it was sitting on the seawall located near the Laboratory. The host had the heaviest "worm-burden" thus far encountered in any of the birds examined. Other trematodes encountered in the intestine included numerous *Drepanocephalus* sp., *Mesostephanus* sp., and *Parascocotyle diminuta* (Stunkard and Haviland, 1924) Hutton and Sogandares-Bernal, 1958, Fig. 2c. Also, there were seven specimens of *Clinostomum attenuatum* Cort, 1913, (Fig. 1a) removed from the trachea. *Hysteromorpha triloba* has been reported from *Phalacrocorax aristotelis* (L.), *P. auritus auritus* (Less.), *P. auritus albociliatus* Ridgway, *P. carbo carbo* (L.), *P. carbo hanedae* Kuroda, *P. carbo novachollandiae* Steph., *P. fuscescens* (Vieill.), *P. olivaceus* (Humb.), and *P. sulcirostris* (Brandt). The present report appears to be the first record of the parasite from *P. auritus floridanus* (Audub.). *H. triloba* is a cosmopolitan species being reported from Europe, North and South America, Japan, India and Australia. Recently Hugghins (1953, 1954) has added information to the knowledge of the life history of this trematode.

Family OPISTHORCHIDAE Luhe, 1901

9. *Pachytrema sanguineum* (Linton, 1928) Purvis, 1937

Fig. 2e

HOST: *Larus atricilla* Linnaeus, laughing gull.
INCIDENCE OF INFECTION: In 2 of 6 specimens.
NUMBERS: 1, 2.
LOCATION: Gall bladder.

LOCALITIES: South of Big Island, Old Tampa Bay, and Bayboro Harbor, Tampa Bay, Florida.
DATES: October 15, March 27, 1958.

Discussion. Linton (1928) described a single specimen of a distome from the intestine of the laughing gull under the name *Minuthorchis sanguineum* n. g., n. sp., Purvis (1937) and Brinkman (1942) considered *Minuthorchis* to be a synonym of *Pachytrema,* but both of these workers agreed that *P. sanguineum* should be retained as a valid species at least until further study should prove otherwise. We have obtained three specimens of what we consider to be *P. sanguineum* from the gall bladder of the laughing gull. One gull had a pustulent gall bladder and contained two contracted worms. The specimen shown in Figure 2e is from the second gull. The seminal vesicle was only faintly visible immediately posterior and sinistral to the pharynx. A seminal receptacle was not observed. A comparison between measurements reported by Linton (1928) for his specimen and measurements made from one of our specimens are given in Table 2.

TABLE 2
MEASUREMENTS IN MM OF TWO SPECIMENS OF *Pachytrema sanguineum* (LINTON.)

	Linton's Specimen	Our Specimen
Body Length	8.8	7.6
Maximum Body Width	5.6	4.9
Oral Sucker Diameter	0.46	0.43
Pharynx Diameter	0.18	0.16
Diameter of Ventral Sucker	0.45	0.36
Right Testis	0.52 x 0.70	0.40 x 0.64
Left Testis	0.38 x 0.56	—
Ovary	0.46 x 0.56	0.41 x 0.43
Uncollapsed uterine ova	0.047 x 0.088	0.048 x 0.088
	0.045 x 0.090	0.042 x 0.095

Family ECHINOSTOMATIDAE

10. *Stephanoprora denticulata* (Rudolphi, 1802) Odhner, 1910
Fig. 2d

HOST: *Larus argentatus smithsonianus* Coues., herring gull.
INCIDENCE OF INFECTION: 1 of 1 specimen.
NUMBER: 1.
LOCALITY: 2 miles east of Albert Whitted Airport, St. Petersburg, Tampa Bay, Florida, new locality record.
DATE: October 11, 1958.

Discussion. Linton (1928) reported this worm under the name *Mesorchis pseudoechinatus* (Olsson) from the intestine of *Larus argentatus, L. atricilla, L. delawarensis, L. marinus, L. philadelphia, Colymbus auritus, C. holbolli,* and *Gavia immer,* from the Woods Hole area. Dawes (1956) considered *Distoma pseudechinatum* Olsson, 1876, and *Stephanoprora denticula* (Rudolphi) synonyms. The anterior part of the body to the level of the anterior testis of *S. denticulata* is spinose. Figure 2d does not show these cuticular spines.

Summary

1. New locality records are given for the following trematodes: *Clinostomum attenuatum* Cort, 1913; *Phagicola longa* (Ransom, 1920) Price, 1932; *Parascocotyle diminuta* (Stunkard and Haviland, 1924) Hutton and Sogandares-Bernal, 1958; *Cryptocotyle lingua* (Creplin, 1825) Fischoeder, 1903; *Galactosomum cochleariforme* (Rudolphi, 1819) Pratt, 1911; *Mesostephanus appendiculatoides* (Price, 1934) Lutz, 1935; *Hysteromorpha triloba* (Rudolphi, 1819) Lutz, 1931; *Pachytrema sanguineum* (Linton, 1928) Purvis, 1937; and *Stephanoprora denticulata* (Rudolphi, 1802) Odhner, 1910.

2. New host records are as follows: *Clinostomum attenuatum* in *Phalacrocorax auritus floridanus* (Audubon); *Phagicola longa* in *Casmerodius albus egretta* (Gmelin), *Mugil curema* Valenciennes, *M. trichodon* Poey; *Parascocotyle diminuta* in *Phalacrocorax auritus floridanus* (Audub.), *Hydranassa tricolor ruficollis* (Gosse), *Fundulus similis* (Baird and Girard); *Galactosomum* sp. in *Larus atricilla* L.; *Mesostephanus appendiculatoides* in *Pelecanus occidentalis carolinensis* Gmelin, *Mugil cephalus* L., *M. curema* Valenciennes, *M. trichodon* Poey; *Hysteromorpha triloba* in *Phalacrocorax auritus floridanus* (Audub.).

3. Information pertaining to the exact location of each trematode species within its respective host(s) is given when possible.

4. Notes are given on phases of the life histories of *Mesostephanus appendiculatoides, Phagicola longa* and *Parascocotyle diminuta.*

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A CONTRIBUTION TO THE BIOLOGY AND POSTLARVAL DEVELOPMENT OF THE SARGASSUM FISH, *HISTRIO HISTRIO* (LINNAEUS), WITH A DISCUSSION OF THE *SARGASSUM* COMPLEX[1]

JUDITH A. ADAMS
The Marine Laboratory, University of Miami

ABSTRACT

The early development of the Sargassum fish, *Histrio histrio* (Linnaeus), is described, based upon a collection of 44 larval and juvenile specimens from the Florida Current. Growth, biology, feeding and relationship to the Sargassum complex are discussed. Specimens at various stages of development are illustrated.

INTRODUCTION

The fishes of the family Antennariidae have attracted considerable interest because of their curious form, coloration, and behavior. Reef and bank-dwelling antennariids are widely distributed throughout warm, shallow seas in the Atlantic, Pacific, and Indian Oceans, and the pelagic member of the family, *Histrio histrio,* occurs in floating weed over a similar area, although wind and current may at times carry these drifters far into temperate waters. Despite, however, the interest and availability of this group, its taxonomy was not clarified until quite recently (Barbour, 1942; Schultz, 1957), and many reports were buried in the proliferating synonomy. *Histrio histrio* alone, though now regarded as belonging to a monotypic genus, has seventeen synonyms as listed by Schultz (1957).

Larval stages and eggs of the Antennariidae were unknown to early workers; this led several respected biologists to attribute erroneously the "nests" of flying fish to *Histrio*. Subsequently, non-fertile egg rafts of solitary *Histrio* females were observed in aquaria. In 1954 Mosher successfully paired ripe males and females in aquaria at the Lerner Marine Laboratory, Bimini, Bahamas, and recorded the spawning and fertilization of *Histrio* egg rafts. Mosher (1954) described the courtship and mating of these fish, and collected, preserved, and photographed a series of developmental stages from cleavage to the eleventh day, at which time the larvae died. Further information on the embryology

[1]Contribution No. 259 from The Marine Laboratory, University of Miami. This study is part of a thesis presented in partial fulfillment of the degree of Master of Science in Marine Sciences. This is a technical report to the National Geographic Society.

and prolarval development of *Histrio* was contributed by Rasquin (1958) in a study which was also based on aquarium specimens.

While postlarvae of *Histrio* and closely related genera are probably quite common in collections, there has been no attempt in the literature to identify them to species. Although Mosher succeeded in raising *Histrio* prolarvae to a length of 1.6 mm in aquaria, her specimens did not resemble the youngest stages found in plankton tows, probably for reasons discussed later.

The writer, working with a large number of postlarval antennariids in the collection of The Marine Laboratory, was able to separate out a series of postlarval *Histrio* from 1.9 mm standard length to identifiable juveniles. The following description and discussion are based upon this series of planktonic larvae.

This paper is one of a series resulting from the National Geographic Society—University of Miami Pelagic Fish Life History Program. The author is deeply grateful to the National Geographic Society for its financial support of this program, and to Dr. Gilbert L. Voss for his supervision and guidance. Thanks are also due Dr. John E. Randall and Dr. C. Richard Robins for their valuable suggestions, and Dr. Hilary B. Moore, Dr. C. P. Idyll, and Mr. Luis R. Rivas for their criticisms and assistance. Finally, Dr. Vladimir Walters, Assistant Curator of Fishes of the American Museum of Natural History, kindly loaned a series of eggs and prolarvae raised in aquaria by Miss Priscilla Rasquin, also of the American Museum of Natural History, and for this the author wishes to express her appreciation.

Materials and Methods

Collection of Specimens. Most of the forty-four postlarval and juvenile specimens studied were obtained in the Florida Current off Miami from two stations which were routinely occupied by vessels of The Marine Laboratory in connection with the fish larva program and plankton investigations. The first station, designated NG, was located on the west side of the Florida Current about ten miles east of the Miami sea buoy (25°43′ to 26°08′N, 79°23′ to 79°56′W). The depth at the NG station was between 150-350 meters. The second routine station, designated SL, was on the east side of the Florida Current about five miles west of Gun Cay, Bahamas (25°35′N, 79°25′W). The depth at the SL station was approximately 740 meters. Both these stations were occupied at least once a month, weather permitting, for a

24-hour period. Further data concerning standard haul procedure, nets, and hydrographic instruments have been given by N. Voss (1954).

The material from the SL and NG stations was supplemented by four specimens taken off Upper Matecumbe Key in the Florida Keys and by three specimens from the lower Straits of Florida. One speci-

TABLE 1

Histrio histrio (LINNAEUS). STATION DATA FOR SPECIMENS STUDIED

Station	Date	Time	Location	Depth M	Surface Temp. °C	No. of Spec.
SL 4 A	——	——	——	—	—	1
SL 10 B-2	12/ 9/52	1845	25°35′N, 79°25′W	400	25.7	1
SL 11 A-5	1/22/53	2015	"	—	24.8	1
E-2	1/23/53	1110	"	—	24.8	1
SL 17 B-4	6/11/53	1950	"	400	29.6	1
B-5	6/11/53	2105	"	300	29.6	1
D-1	6/12/53	0245	"	500	29.6	1
SL 18 C-7	7/ 2/53	0950	"	100	28.1	1
SL 19 A-4	8/14/53	1525	"	400	29.8	1
B-8	8/14/53	0035	"	0	29.8	1
D-8	8/14/53	1035	"	0	29.8	1
SL 22 C-6	11/ 5/53	2342	"	0	25.9	1
SL 23 D-5	12/10/53	1225	"	—	26.1	1
SL 26 A-3	6/21/54	2255	"	—	28.6	1
SL 28 B-0	8/11/54	1320	"	—	31.4	1
SL 29 B-4	9/14/54	0000	"	—	29.2	1
SL 30 A-6	11/28/54	2015	"	—	24.8	1
SL 37 B-2	——	——	"	—	—	1
SL 42 A-1	11/ 9/55	0200	"	50	27.0	1
A-4	11/ 9/55	0030	"	350	27.0	1
SL 43 B-2	2/23/56	——	"	—	18.5	1
SL 44 B-1	5/ 8/56	2215	"	0	26.7	1
SL 45 B-6	9/13/56	0915	25°35′N, 79°25′W	600	28.2	1
NG 11 A-3	12/ 9/50	1930	26°08′N, 79°56′W	125	—	2
A-4	12/ 9/50	1930	"	75	—	1
NG 22 B	3/ 7/51	1142	"	25	—	1
NG 39 B	2/ 4/52	1105	"	50	—	1
FR 34	5/ 8/53	1455	25°43′N, 79°18′W	0	24.9	1
IS 2	3/31/53	2015	off Miami Beach	0	—	1
Supl. 2	6/—/52	——	off Matecumbe	0	—	4
Supl. 28	11/ 9/55	——	middle Fla. Curr.	0	—	1
Supl. 46	2/20/56	——	Bear Cut, Miami	0	—	1
Supl. 75	6/ 8/56	0946	off S. Bimini	—	28.3	1
Supl. 76	3/14/56	——	off Cat Cay	—	25.9	1
Supl. 79	6/ 6/56	——	off Bimini	0	—	2
Yuc. Sta. 10	4/ 2/54	0300	23°49′N, 82°31′W	0	27.1	3
Yuc. Sta. 58	4/—/54	0430	20°49′N, 81°43′W	0	26.9	1

men was taken in the Caribbean north of Grand Cayman. Several specimens were obtained from Biscayne Bay and inshore Miami waters. Complete station data for all specimens studied are given in Table 1. The terminology herein applied to early fish stages is that of Hubbs (1943).

Measurements, Proportions, and Counts. All measurements of specimens from 1.9 to 10.0 mm standard length were taken with an ocular micrometer. Larger specimens were measured with a pair of dividers. All lateral measurements and counts were made on the left side. Total length was taken only in the smaller specimens as a means of comparison with prolarval material from the American Museum, since it was otherwise of little value to this study. Measurements are in millimeters.

Definitions of the measurements used are as follows:

STANDARD LENGTH is measured from the tip of the snout to the middle of the caudal base, since the urostyle in the smallest specimen is already formed.
HEAD LENGTH is measured from the tip of the snout to the posterior edge of the opercle; the "siphon" bearing the gill opening is disregarded.
SNOUT LENGTH is measured from the tip of the upper jaw to the anterior margin of the bony orbit.
ORBIT DIAMETER refers to the greatest horizontal diameter of the bony orbit, inside measurement.
PRE-SOFT DORSAL LENGTH is measured from the tip of the snout to the origin of the soft dorsal fin.
PRE-PELVIC LENGTH is measured from the tip of the snout to the insertion of the pelvics.
PRE-ANAL LENGTH refers to a measurement from the tip of the snout to the origin of the anal fin.
DEPTH was taken but not used in this study, since the highly distensible stomach is often inflated with air, water or food, rendering the measurements useless.

Proportions or indices are expressed as a percentage of standard length. Snout length, orbit diameter, and pre-pelvic length are also expressed as percentages of the head length.

Development

Specimens Studied.

Twenty-five specimens (1.9-5.0 mm standard length), from 17 regular SL stations.

Five specimens (2.6-14.9 mm standard length), from 3 regular NG stations.

One specimen (9.5 mm standard length), Marine Laboratory FR 34, 25°43′N, 79°18′W.

TABLE 2

Histrio histrio (Linnaeus). Measurements in mm of Specimens Studied

Station	Standard Length	Head Length	Snout Length	Orbit Diameter	Pre-soft Dorsal Length	Pre-pelvic Length	Pre-anal Length
SL 22 C-6	1.9	0.9	0.2	0.5	1.5	—	1.5
SL 44 B-1	2.0	0.8	0.2	0.4	1.4	—	1.6
SL 17 B-4	2.1	0.8	0.2	0.5	1.4	—	1.5
SL 29 B-4	2.4	0.9	0.2	0.3	1.4	—	1.7
SL 42 A-4	2.5	1.0	0.2	0.5	1.5	—	1.6
SL 19 A-4	2.5	1.2	0.3	0.5	1.7	0.9	2.0
SL 11 E-2	2.6	1.3	0.3	0.5	1.8	0.8	2.0
NG 11 A-3	2.6	1.0	0.2	0.5	1.5	0.7	1.9
SL 19 D-8	2.6	1.1	0.3	0.5	1.6	0.7	1.8
SL 17 B-5	2.7	1.2	0.3	0.6	1.8	0.8	2.1
SL 10 B-2	2.7	1.2	0.3	0.6	1.8	0.8	2.3
SL 19 B-8	2.7	1.4	0.3	0.6	1.8	0.8	2.1
SL 42 A-1	2.9	1.1	0.2	0.5	1.7	0.6	2.0
SL 4 A	2.9	1.2	0.3	0.5	1.6	0.7	2.2
NG 11 A-3	3.1	1.2	0.2	0.5	1.7	1.7	2.3
SL 30 A-6	3.3	1.1	0.2	0.6	1.6	1.0	2.4
SL 11 A-5	3.3	1.2	0.3	0.5	1.9	0.8	2.3
SL 17 D-1	3.4	1.5	0.3	0.7	1.9	1.3	2.8
NG 11 A-4	3.5	1.4	0.3	0.6	1.8	—	2.7
SL 45 B-6	3.6	1.3	0.2	0.6	2.0	0.9	2.6
SL 18 C-7	3.6	1.3	0.3	0.6	1.9	0.9	2.4
SL 43 B-2	3.9	1.8	0.3	0.5	2.2	0.8	3.0
NG 39 B	4.0	1.7	0.4	0.7	2.4	1.4	3.1
SL 28 B-0	4.1	2.0	0.4	0.7	2.6	1.3	3.3
SL 23 D-5	4.3	1.9	0.4	0.9	2.7	1.2	3.0
SL 26 A-3	4.4	1.8	0.4	0.7	2.4	1.7	3.4
SL 37 B-2	5.0	2.1	0.3	0.7	2.6	1.2	3.6
Supl. 75	9.0	2.9	0.6	1.1	5.0	2.2	6.5
FR 34	9.5	3.8	0.7	1.1	4.7	2.4	6.5
Yuc. Sta. 58	10.0	4.7	1.4	1.6	6.1	4.2	7.3
Supl. 46	10.1	4.9	1.8	1.7	6.1	5.0	7.5
Supl. 79	10.7	4.8	1.6	1.9	6.1	4.7	7.6
Supl. 76	11.5	5.1	1.6	1.7	5.9	4.6	8.8
Supl. 2	11.5	5.6	1.6	1.9	6.6	4.0	9.4
Supl. 2	11.5	5.6	1.8	1.8	6.1	4.5	9.1
Supl. 79	12.5	5.2	2.0	2.0	7.6	5.9	9.4
Yuc. Sta. 10	14.0	6.0	2.0	2.0	7.5	6.0	10.1
Yuc. Sta. 10	14.0	5.9	1.4	1.8	7.5	6.0	10.0
NG 22 B	14.9	6.9	2.0	2.2	9.2	6.5	11.0
Supl. 2	15.2	6.0	1.6	2.0	7.4	4.0	11.0
Yuc. Sta. 10	15.2	6.8	1.8	2.1	8.4	6.6	11.9
IS 2	15.5	7.0	2.0	2.2	8.8	6.7	11.7
Supl. 2	17.0	6.4	2.0	2.0	9.0	6.4	11.0
Supl. 28	19.0	8.0	2.0	2.0	10.5	6.0	13.0

TABLE 3

Histrio histrio (LINNAEUS). FIN-RAY COUNTS OF SPECIMENS STUDIED

Station	Standard Length (mm)	Dorsal Fin	Anal Fin	Pectoral Fin	Pelvic Fin	Caudal Fin
SL 22 C-6	1.9	——	—	—	—	9
SL 44 B-1	2.0	—,10	7	—	—	9
SL 17 B-4	2.1	—, 9?	—	—	—	—
SL 29 B-4	2.4	—,11	—	—	—	9
SL 42 A-4	2.5	—,11?	7	—	—	9
SL 19 A-4	2.5	—,12	7	—	—	—
SL 11 E-2	2.6	—,12	7	—	—	—
NG 11 A-3	2.6	—,11	—	—	—	9
SL 19 D-8	2.6	—,10	7	—	—	—
SL 17 B-5	2.7	—,11	6?	—	—	—
SL 10 B-2	2.7	—,12	7	—	—	—
SL 19 B-8	2.7	—,12	7	—	—	9
SL 42 A-1	2.9	——	7	—	—	9
SL 4 A	2.9	—,12	7	—	—	—
NG 11 A-3	3.1	—, 9?	6?	—	—	9
SL 30 A-6	3.3	—,12	7	—	—	9
SL 11 A-5	3.3	—,12	7	—	—	9
SL 17 D-1	3.4	—,11	7	—	—	—
NG 11 A-4	3.5	—,12	7	—	—	9
SL 45 B-6	3.6	—,12	7	—	5	9
SL 18 C-7	3.6	—,12	7	—	5?	9
SL 43 B-2	3.9	—,11	7	—	—	9
NG 39 B	4.0	—,11	6	10?	5	9
SL 28 B-0	4.1	—,12	7	—	—	—
SL 23 D-5	4.3	—,12	7	—	—	9
SL 26 A-3	4.4	—,12	7	—	—	9
SL 37 B-2	5.0	—,12	7	10	5	9
Supl. 75	9.0	III,11	7	—	5	9
FR 34	9.5	III,12	7	10	5	9
Yuc. Sta. 58	10.0	III,12	7	10	5	9
Supl. 46	10.1	III,12	7	10	5	9
Supl. 79	10.7	III,12	7	10	5	9
Supl. 76	11.5	III,12	7	10	5	9
Supl. 2	11.5	III,12	7	10	5	9
Supl. 2	11.5	III,12	7	10	5	9
Supl. 79	12.5	III,10	7	10	5	9
Yuc. Sta. 10	14.0	III,12	7	10	5	9
Yuc. Sta. 10	14.0	III,11	7	10	5	9
NC 22 B	14.9	III,—	7	10	5	9
Supl. 2	15.2	III,12	7	10	5	9
Yuc. Sta. 10	15.2	III,12	7	10	5	9
IS 2	15.5	III,12	7	10	5	9
Supl. 2	17.0	III,12	7	10	5	9
Supl. 28	19.0	III,12	7	10	5	9

TABLE 4

Histrio histrio (LINNAEUS). BODY PROPORTIONS OF SPECIMENS STUDIED

Station	Standard Length (mm)	Head Index	Snout Index	Orbit Index	Pre-soft Dorsal Index	Pre-pelvic Index	Pre-anal Index
SL 22 C-6	1.9	47.4	10.5	26.3	78.9	—	78.9
SL 44 B-1	2.0	40.0	10.0	20.0	70.0	—	80.0
SL 17 B-4	2.1	38.1	9.5	23.8	66.6	—	71.4
SL 29 B-4	2.4	37.5	8.3	12.5	58.3	—	70.8
SL 42 A-4	2.5	40.0	8.0	20.0	60.0	—	64.0
SL 19 A-4	2.5	48.0	12.0	20.0	68.0	36.0	80.0
SL 11 E-2	2.6	50.0	11.5	19.2	69.2	30.8	76.9
NG 11 A-3	2.6	38.5	7.7	19.2	57.7	26.9	73.1
SL 19 D-8	2.6	42.3	11.5	19.2	61.5	26.9	69.2
SL 17 B-5	2.7	44.4	11.1	22.2	66.7	29.6	77.8
SL 10 B-2	2.7	44.4	11.1	22.2	66.7	29.6	85.2
SL 19 B-8	2.7	51.9	11.1	22.2	66.7	29.6	77.8
SL 42 A-1	2.9	37.9	6.9	17.2	58.6	20.7	69.0
SL 4 A	2.9	41.4	10.3	17.2	55.2	24.1	75.9
NG 11 A-3	3.1	38.8	6.5	16.1	61.3	54.8	74.2
SL 30 A-6	3.3	33.3	6.1	18.2	48.5	30.3	72.7
SL 11 A-5	3.3	36.4	9.1	15.2	57.6	24.2	69.7
SL 17 D-1	3.4	44.1	8.8	20.6	55.9	38.2	82.4
NG 11 A-4	3.5	40.0	8.6	17.1	51.4	—	77.1
SL 45 B-6	3.6	36.1	5.6	16.7	55.6	25.0	72.2
SL 18 C-7	3.6	36.1	8.3	16.7	52.8	25.0	66.7
SL 43 B-2	3.9	46.2	7.8	12.8	56.4	20.5	76.9
NG 39 B	4.0	42.5	10.0	17.5	60.0	35.0	77.5
SL 28 B-0	4.1	48.8	9.8	17.1	63.4	31.7	80.5
SL 23 D-5	4.3	44.2	9.3	20.9	62.8	27.9	69.8
SL 26 A-3	4.4	40.9	9.1	15.9	54.5	38.6	77.3
SL 37 B-2	5.0	42.0	6.0	14.0	52.0	24.0	72.0
Supl. 75	9.0	32.2	6.7	12.2	55.6	24.4	72.2
FR 34	9.5	40.0	7.4	11.6	49.5	25.3	68.4
Yuc. Sta. 58	10.0	47.0	14.0	16.0	61.0	42.0	73.0
Supl. 46	10.1	45.0	16.5	15.6	56.1	46.0	68.9
Supl. 79	10.7	44.9	15.0	17.8	57.0	43.9	71.0
Supl. 76	11.5	44.3	13.9	14.8	51.3	40.0	76.5
Supl. 2	11.5	48.7	13.9	16.5	57.4	34.8	81.7
Supl. 2	11.5	48.7	15.7	15.7	53.0	39.1	79.1
Supl. 79	12.5	41.6	16.0	16.0	60.8	47.2	75.2
Yuc. Sta. 10	14.0	42.9	14.3	14.3	53.6	42.9	72.1
Yuc. Sta. 10	14.0	42.1	10.0	12.9	53.6	42.9	71.4
NG 22 B	14.9	46.3	13.4	14.8	61.7	43.6	73.8
Supl. 2	15.2	39.5	10.5	13.2	48.7	26.3	72.4
Yuc. Sta. 10	15.2	44.7	11.8	13.8	55.3	43.4	78.3
IS 2	15.5	45.2	12.9	14.2	56.8	43.2	75.5
Supl. 2	17.0	37.6	11.8	11.8	52.9	37.6	64.7
Supl. 28	19.0	42.1	10.5	10.5	55.3	31.6	68.4

TABLE 5

Histrio histrio (LINNAEUS). HEAD PROPORTIONS OF SPECIMENS STUDIED

Station	Standard Length (mm)	Head Length	Snout-Head Index	Orbit-Head Index	Prepelvic Head Index
SL 22 C-6	1.9	0.9	22.2	55.6	——
SL 44 B-1	2.0	0.8	25.0	50.0	——
SL 17 B-4	2.1	0.8	25.0	62.5	——
SL 29 B-4	2.4	0.9	22.2	33.3	——
SL 42 A-4	2.5	1.0	20.0	50.0	——
SL 19 A-4	2.5	1.2	25.0	41.7	75.0
SL 11 E-2	2.6	1.3	23.1	38.5	61.5
NG 11 A-3	2.6	1.0	20.0	50.0	170.0
SL 19 D-8	2.6	1.1	27.3	45.5	63.6
SL 17 B-5	2.7	1.2	25.0	50.0	66.7
SL 10 B-2	2.7	1.2	25.0	50.0	66.7
SL 19 B-8	2.7	1.4	21.4	42.9	57.1
SL 42 A-1	2.9	1.1	18.2	45.5	54.5
SL 4 A	2.9	1.2	25.0	41.7	58.3
NG 11 A-3	3.1	1.2	16.6	41.7	141.7
SL 30 A-6	3.3	1.1	18.2	54.5	90.9
SL 11 A-5	3.3	1.2	25.0	41.7	66.7
SL 17 D-1	3.4	1.5	20.0	46.7	86.7
NG 11 A-4	3.5	1.4	21.4	42.9	——
SL 45 B-6	3.6	1.3	15.4	46.2	69.2
SL 18 C-7	3.6	1.3	23.1	46.2	69.2
SL 43 B-2	3.9	1.8	16.7	27.8	44.4
NG 39 B	4.0	1.7	23.5	41.2	82.4
SL 28 B-0	4.1	2.0	20.0	35.0	65.0
SL 23 D-5	4.3	1.9	21.1	47.4	63.2
SL 26 A-3	4.4	1.8	22.2	38.9	94.4
SL 37 B-2	5.0	2.1	14.3	33.3	57.1
Supl. 75	9.0	2.9	20.7	37.9	75.9
FR 34	9.5	3.8	18.4	28.9	63.2
Yuc. Sta. 58	10.0	4.7	29.8	34.0	89.4
Supl. 46	10.1	4.9	36.7	34.7	102.0
Supl. 79	10.7	4.8	33.3	39.6	97.9
Supl. 76	11.5	5.1	31.4	33.3	90.2
Supl. 2	11.5	5.6	28.6	33.9	71.4
Supl. 2	11.5	5.6	32.1	32.1	80.4
Supl. 79	12.5	5.2	38.5	38.5	113.5
Yuc. Sta. 10	14.0	6.0	33.3	33.3	100.0
Yuc. Sta. 10	14.0	5.9	23.7	30.5	101.7
NG 22 B	14.9	6.9	29.0	31.9	94.2
Supl. 2	15.2	6.0	26.7	33.3	66.7
Yuc. Sta. 10	15.2	6.8	26.5	30.9	97.1
IS 2	15.5	7.0	28.6	31.4	95.7
Supl. 2	17.0	6.4	31.3	34.4	100.0
Supl. 28	19.0	8.0	25.0	25.0	75.0

One specimen (15.5 mm standard length), Marine Laboratory IS 2, about four miles east of Miami Beach.
One specimen (10.1 mm standard length), Marine Laboratory Supl. 46, from Bear Cut, Biscayne Bay.
One specimen (9.0 mm standard length), Marine Laboratory Supl. 75, one and one-half miles off S. Bimini, Bahamas.
Two specimens (10.7 and 12.5 mm standard length), Marine Laboratory Supl. 79, off Bimini, Bahamas.
One specimen (11.5 mm standard length), Marine Laboratory Supl. 76, off Cat Cay, Bahamas.
One specimen (19.0 mm standard length), Marine Laboratory Supl. 28, from the middle of the Florida Current.
Four specimens (11.5, 11.5, 15.2, 17.0 mm standard length), Marine Laboratory Supl. 2, off Upper Matecumbe Key, Florida Keys.
Three specimens (14.0, 14.0, 15.2 mm standard length), Marine Laboratory Yucatan Station 10, off the north coast of Cuba.
One specimen (10.0 mm standard length), Marine Laboratory Yucatan Station 58, in the Caribbean north of Grand Cayman.

Station data for the specimens studied are given in Table 1. Measurements of these specimens are found in Table 2, fin-ray counts in Table 3, body proportions in Table 4, and head proportions in Table 5.

Description of Representative Specimens

Seven specimens were chosen as representative of changes occurring in the postlarval and juvenile stages of *Histrio histrio*. These specimens are figured (Figs. 1-3), and the discussion below is primarily based on these individuals, supplemented by references to other members of the series where necessary.

2.0 mm standard length (Fig. 1A).

Figure 1A illustrates a typical 2.0 mm specimen. Although one slightly smaller specimen (1.9 mm standard length) was examined, it was in very battered condition. There were no apparent differences between the two which could not be attributed to damage suffered by the smaller.

The most salient character of the 2.0 mm larva is the bubble or envelope in which it appears to be enclosed. Unfortunately, this cellophane-like globe is difficult to illustrate. The effect under a binocular microscope is that of a tiny fish contained in a more or less spherical, transparent casing through which the fins project. This "envelope" is

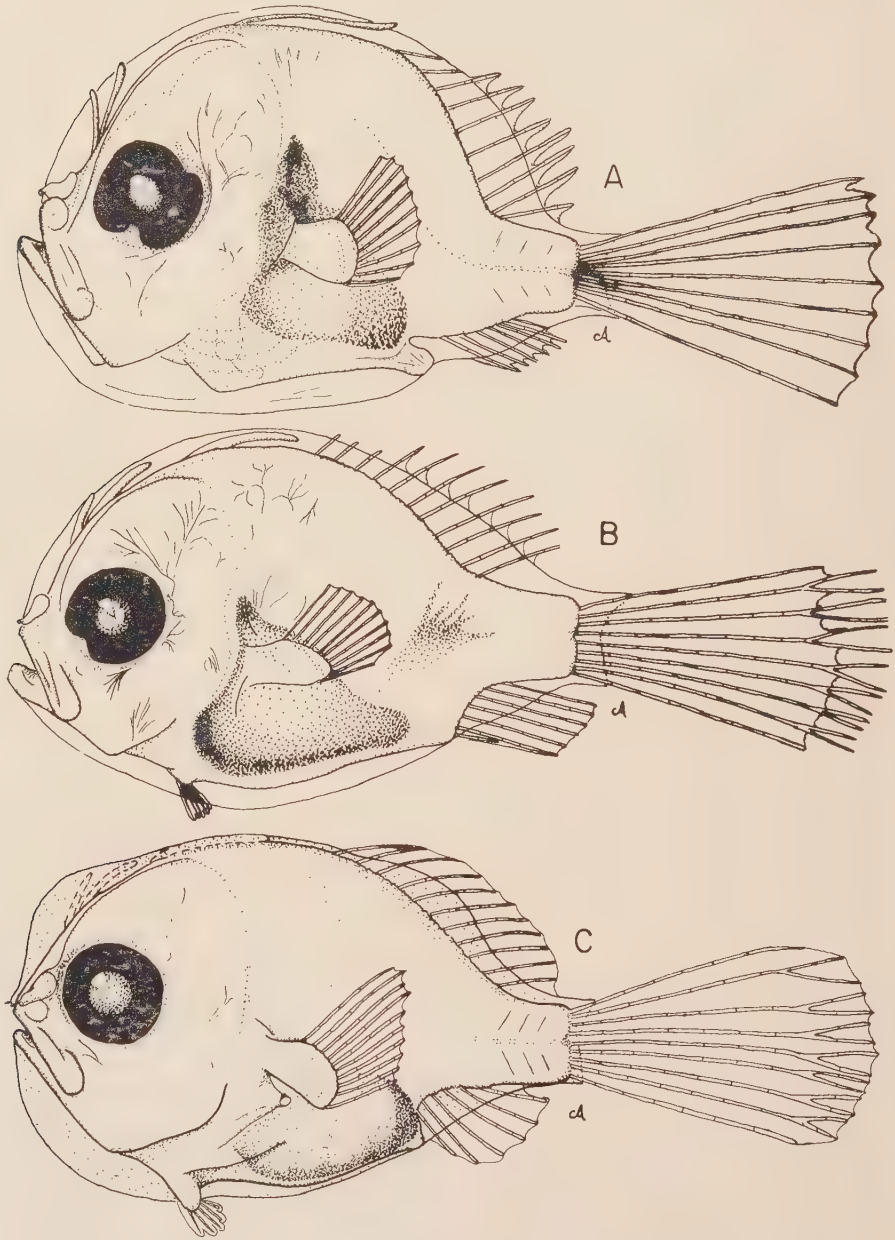

FIGURE 1. Postlarval specimens of *Histrio histrio*. A. 2.0 mm standard length; B. 3.4 mm standard length; C. 4.0 mm standard length.

applied to the body only at mouth and vent, and around the bases of the fins. The appearance of the envelope may be greatly altered by poor preservation, which leads to deflation, wrinkling, and discoloration. Likewise, the envelope, though fairly tough, is thin enough to be easily torn by normal collecting procedures. Thus, in some cases it may be completely torn away from the body, radically altering the appearance of the larva. It is almost irresistible at first sight to regard the bubble as a larval appurtenance which is destined to be discarded in later life. One must trace it in successive larval stages to ascertain that it is indeed the epidermis of the adult fish.

Aside from the integumentary envelope, other important features of the 2.0 mm larva are as follows. The head is relatively large, forming one-third to almost one-half the body length in various individuals; the head parts are also proportionately large at this stage. The eye is doubly notched. (Double or single notching is quite common in young postlarval *Histrio,* although the un-notched, circular eye also is found.) Chromatophores are conspicuous in the head region, and especially around the eye. Pigmentation of the mid-gut is dense and dark. Myotomes are visible to a greater or lesser degree in the caudal and lower dorsal regions.

All fins are present and almost completely formed, the anal and caudal fins having the definitive number of rays (7 and 9 respectively). The soft dorsal has 10 rays of the adult 11 or 12. Pectoral rays are counted with difficulty in the small postlarvae, so these data are not included in Table 3. However, the adult count of 10 appeared most often, and, since the pectoral fin develops first, it is probable that a pectoral fin-ray count of 10 applies to all specimens studied. The pelvic fin-bud of the 2.0 mm specimen is dimly visible through the expanded supporting structures of the gills.

The three dorsal spines in some specimens were visible on the head beneath the integumentary envelope; in others, dissection was necessary to verify their presence. The first spine or illicium resembles the other two spines at this stage.

3.4 mm standard length (Fig. 1B).

The pelvic fins first appear externally in postlarvae of 2.6 mm standard length. This condition is illustrated in Figure 1B, which shows a specimen measuring 3.4 mm standard length. The 3.4 mm individual is otherwise quite similar to the 2.0 mm specimen, although its head and constituent parts are relatively smaller. The eye is singly notched.

In all larger larvae the eye is circular. The chromatophore pattern on the head, around the eye, and on the post-cephalic portions of the back is more complex, but the mid-gut pigmentation is still prominent and dense. Although myotomes were not visible in the 3.4 mm specimen figured, they were often visible in the posterior portion of the body in larvae of this size.

The number of soft dorsal rays is increased to eleven, and the caudal rays are branched. Anal rays are more segmented. The thick, soft bases of the median fins are still continuous with the more membranous parts of the envelope, and are not distinguished from it except by texture and greater opacity.

4.0 mm standard length (Fig. 1C).

The 4.0 mm specimen exhibits a shrunken, thickened and almost opaque envelope, which is quite different from the inflated and transparent bubble of younger individuals. The condensed integument is closely applied to the larva in a wide band encircling the fish posterior to the head. Caudad, the envelope is represented only by the still evident and translucent bases of the dorsal, anal, and caudal fins. In the cephalic region the envelope remains drastically separated from the underlying tissues.

The relative proportions of the head and its parts are similar to those noted in the 3.4 mm specimen. The eye is round, and this character is retained henceforth. The paucity of chromatophores in the figured individual is due to severe bleaching. Other specimens in this size range show increased chromatophore development in the cephalic and upper dorsal regions. Myotomes are still evident in the caudal and lower dorsal areas.

The fin-ray counts of the illustrated specimen are: soft dorsal, 11; anal, 6?; pectoral, 10?; pelvic, 5; and caudal, 9. The anal-ray count of 6 may be aberrant, or it may indicate that some larvae attain the definitive count of 7 at a much later stage than do most others. The three dorsal spines are only apparent upon dissection of the now-opaque integumentary envelope, and thus are indicated in the drawing by dotted lines. Gross dissection revealed no difference between the illicium and the other two spines.

5.0 mm standard length (Fig. 2D).

The envelope in the 5.0 mm specimen is extremely wrinkled and shrunken. It has condensed over the entire body, and the tips of the dorsal spines are externally noted as minute bumps. The head is rela-

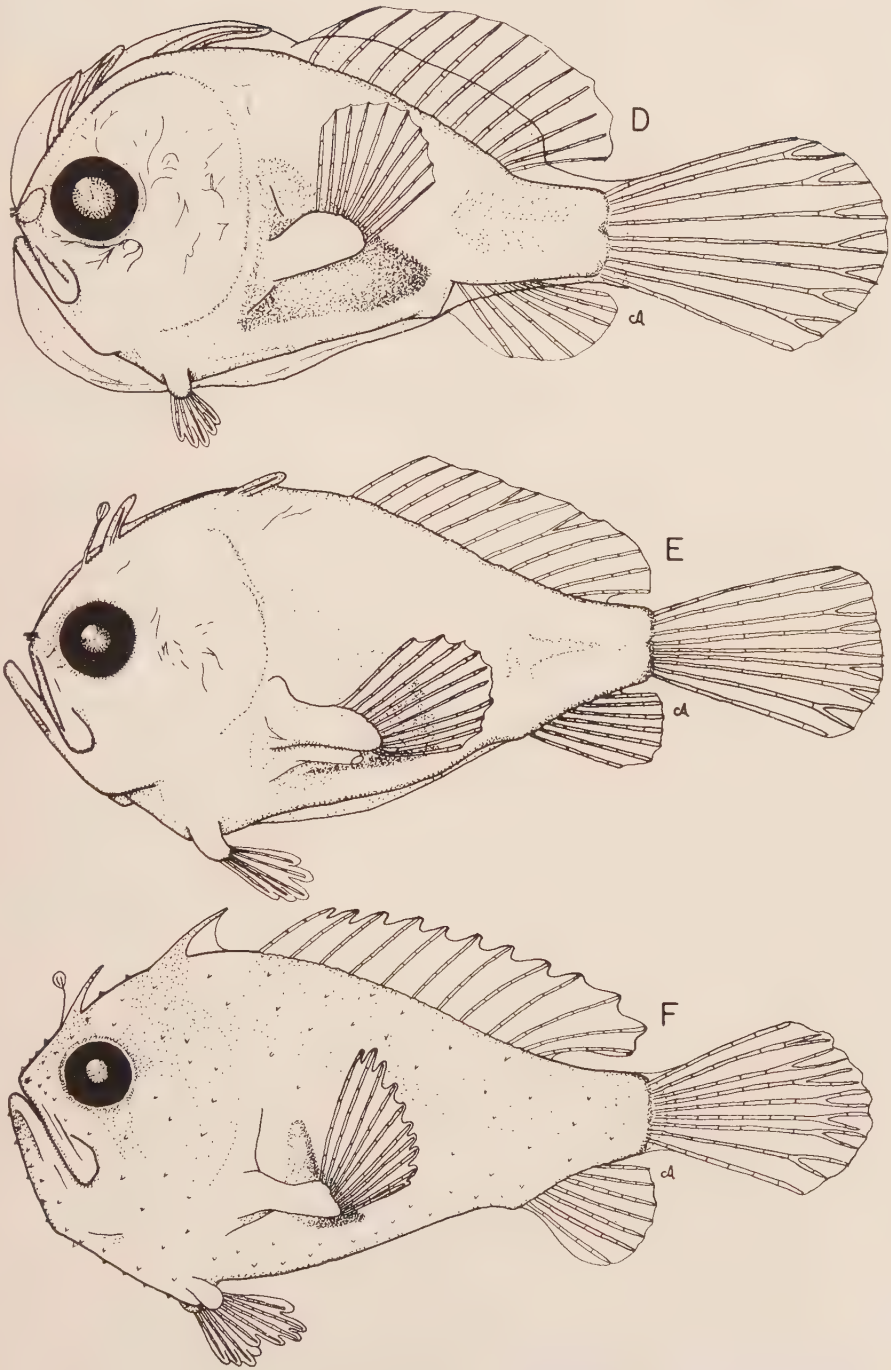

FIGURE 2. Postlarval and juvenile specimens of *Histrio histrio*. D. 5.0 mm standard length; E. 9.0 mm standard length; F. 10.0 mm standard length.

tively shorter and the eye is less conspicuous than in smaller specimens. The chromatophore pattern on the head is extensive, while the mid-gut pigmentation is reduced. Some traces of the myotomes are present.

Unfortunately, the interval between the 5.0 and 9.0 mm specimens is not represented in the series studied. However, one *Histrio* measuring about 7.0 mm standard length was found in the stomach of a 14.0 mm *Histrio histrio*. This specimen was tightly rolled up in the gut of its captor, and as a consequence, accurate measurements were impossible. However, the first and second dorsal spines were externally discrete and the envelope had settled down over the tip of the third spine. This condition is similar to that of the 9.0 mm individual illustrated in Figure 2E.

9.0 mm standard length (Fig. 2E).

The term "envelope" is inappropriate in discussion of the 9.0 mm specimen. Identification of the frail transparent bubble of early postlarval life with the integument of the adult is complete, and separation from the body proper persists only around the bases of the dorsal spines and in the loose skin under the belly. The fleshy bases of the fins are consolidated with the main body outline. The illicium is differentiated. A few dorsal rays are branched, and the pelvic fins are elongated. Mid-gut pigmentation is much faded. Body proportions are quite like those of the 5.0 mm specimen.

10.0 mm standard length (Fig. 2F).

The 10.0 mm specimen marks the transition from postlarva to juvenile. Here the integument is everywhere closely applied to the body, and all three dorsal spines are fully defined. Minute tags have appeared on the skin, and the beginnings of the characteristic color pattern of the adult are evident. Mid-gut pigmentation has shrunk to a small patch. The proportionate size of the head and its parts is slightly increased relative to the 9.0 mm individual.

15.5 mm standard length (Fig. 3G).

Full attainment of adult appearance is shown in the 15.5 mm specimen. The mottled markings of the usual adult color pattern have developed, and the fleshy tags with which the skin is sprinkled have increased in size and profusion. Mid-gut pigmentation is barely discernible. Thick and bumpy skin covers the second and third dorsal spines. Deep indentations of the fin membranes between the rays lend a ragged appearance to the fin margins. The last two dorsal rays and all anal rays are branched. Proportionate growth rates approach the

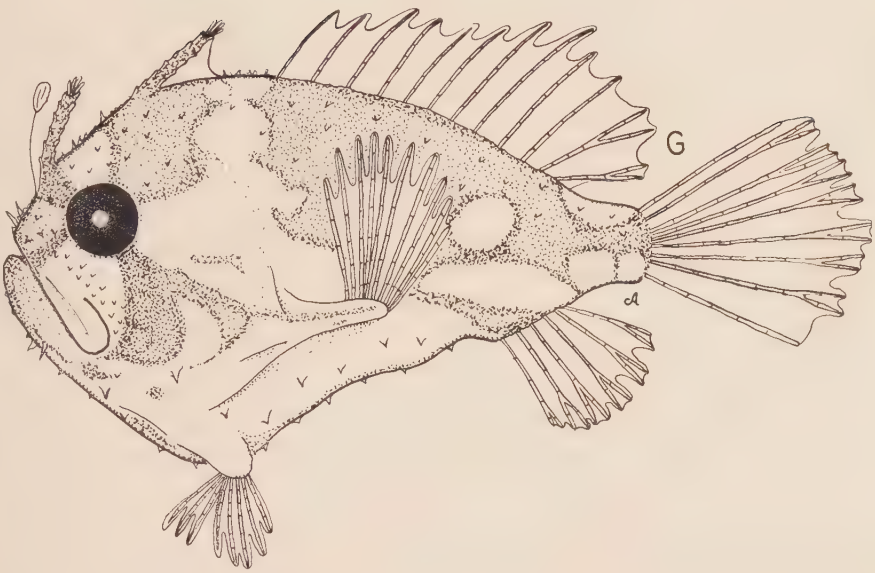

FIGURE 3. Juvenile specimen of *Histrio histrio*. G. 15.5 mm standard length.

isometric state. The fish in all major respects is similar to the larger individuals of the species.

DISCUSSION OF GROWTH

Graphs (Figs. 4, 5) show proportionate changes which occur with increase in body length. The body parts have similar growth curves, differing from each other only in degree. Thus, the various body parts of the postlarvae grow at a nearly constant proportionate rate, the axial rate of growth at times exceeding that of the constituent parts and at times being relatively less. It is possible that the slope of both positive and negative allometric growth is too great, since the lack of specimens in the 5.0-9.0 mm range enforced the extrapolation of the curve in that region and its placement may be unduly low.

The development of young *Histrio* postlarvae into juveniles is a smoothly continuous process, the salient feature of which is the reduction of initially large subdermal spaces. The general appearance becomes more frog-like with increasing age as the pediculate pectoral and pelvic fins develop and the larval envelope contracts around the body. The adult head-chromatophore pattern is established in early postlarval life and is extended as the larvae grow older. Distribution of chromatophores on the body also increases as the mid-gut pigmenta-

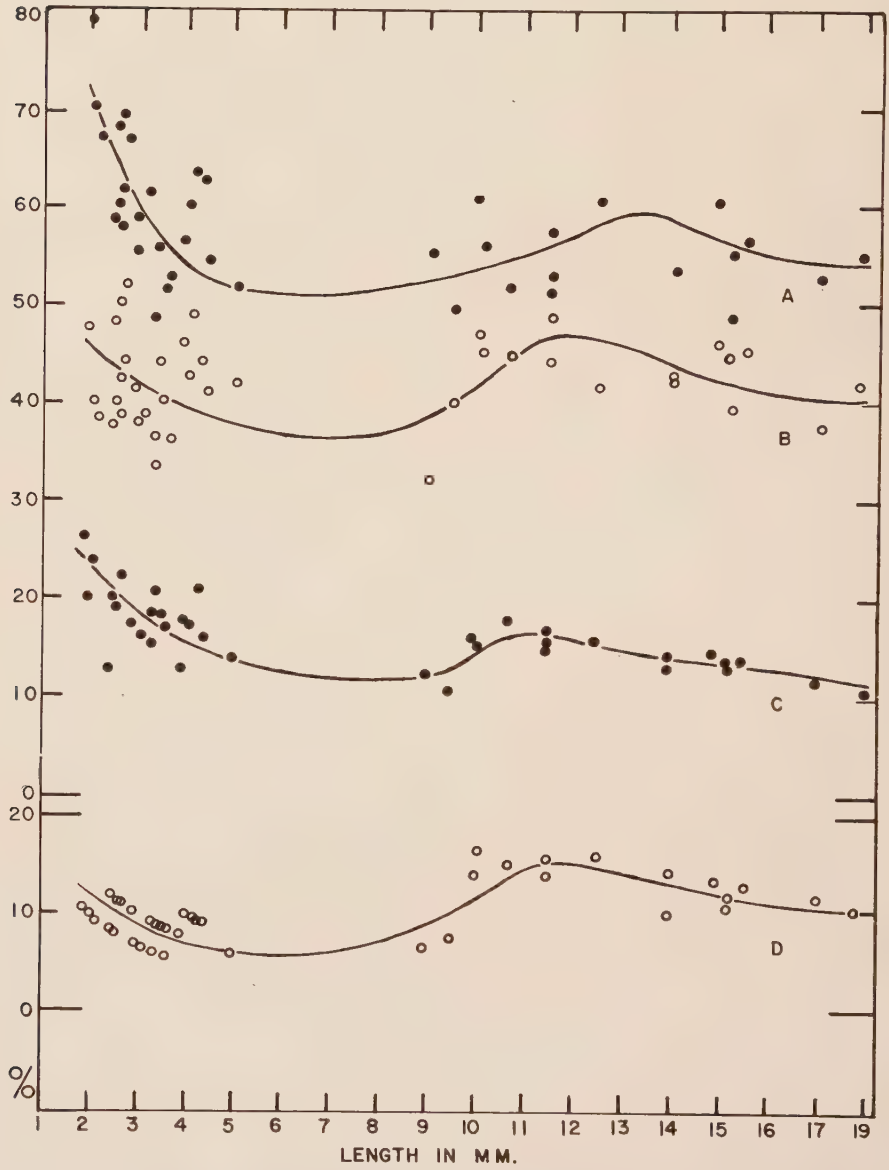

FIGURE 4. Changes in body proportions with growth. A. Pre-soft dorsal length to standard length; B. Head length to standard length; C. Orbit diameter to standard length; D. Snout length to standard length.

tion marking the resorbed yolk diminishes. The erection of all three dorsal spines and the growth of fleshy tags on the thickened, bumpy skin forecast the juvenile state. Proportionate growth rates begin to stabilize at this time.

The developing illicium resembles the second and third dorsal spines in young postlarvae. Between 5.0-7.0 mm standard length this special-

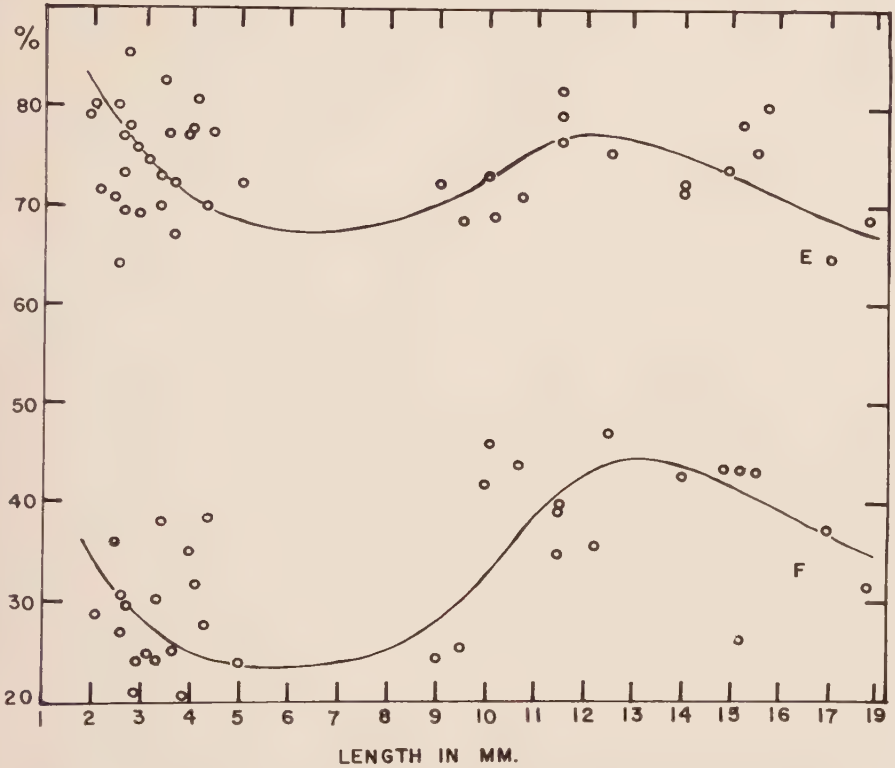

FIGURE 5. Changes in body proportions with growth. E. Pre-anal length to standard length; F. Pre-pelvic length to standard length.

ized first spine becomes externally visible. No specimens were available in this size range, so details of this process are as yet unknown. Histological techniques will be necessary to obtain accurate information on the formation of the illicium.

BIOLOGY

Courtship and Spawning. The courtship and spawning of *Histrio* in

captivity was fully described by Mosher (1954). Cannibalism was not exhibited when ripe males and females were paired, and spawning occurred regularly and frequently for periods exceeding two weeks. This being so, Mosher believed that an established pair in the open sea would remain together until one or both were exhausted.

Ovulation in *Histrio* was accompanied by enormous abdominal swelling and a consequent shift in the center of gravity so that the female paddled snout-down prior to extrusion of the raft. The actual spawning was very brief, taking less than ten seconds.

Seasonal Occurrence of the Young. All but one of the forty-four postlarval and juvenile specimens studied were collected from the Florida Current and adjacent waters; the remaining specimen was taken from the Caribbean north of Grand Cayman. No prolarvae were included in the series. Prolarval *Histrio* may have been taken in this area from time to time, but if so, have not as yet been recognized.

TABLE 6

Histrio histrio (LINNAEUS). SIZE OF LARVAE ACCORDING TO MONTH

Month	Surface Temp. °C*	Size Range of Larvae in mm
January	24.8	2.6 - 3.3
February	18.5	3.9 - 10.1
March	25.9	11.5 - 15.5
April	27.1	10.0 - 15.2
May	24.9 - 26.7	2.0 - 9.5
June	28.3 - 29.6	2.1 - 17.0
July	28.1	3.6
August	29.8 - 31.4	2.5 - 4.1
September	28.2 - 29.2	2.4 - 3.6
October	——	——
November	24.8 - 27.0	1.9 - 19.0
December	25.7 - 26.1	2.6 - 4.3

*From station data

Postlarvae were collected in every month of the year except October. Their absence in that month was probably due to inadequate sampling. Table 6 shows the size range of specimens according to the month in which they were captured. It is interesting that in March and April no specimens under 10.0 mm standard length were taken. This may be coincidence only, but it is also possible that water temperatures in February fall below a minimum spawning temperature for *Histrio*. If so, one would expect to find only the larger postlarvae and juveniles

until warmer surface temperatures are established. Although the spawnings recorded by Mosher (1954) occurred from January to March, the temperature in her aquaria varied between 21-23°C, whereas the surface temperature of the Florida Current may fall to 18°C in February. Therefore, Mosher's observations do not necessarily disagree with the minimum spawning temperature theory. It is impossible to draw positive conclusions from the available data. but present evidence indicates that *Histrio* spawns year-round in the Florida Current area with a possible mid-winter interruption of reproductive activity.

Food. Stomach contents of all specimens studied are recorded in Table 7. The stomachs of most of the smaller fish were empty, but one fish 2.1 mm standard length contained three unidentifiable fish larvae, one copepod, a medusa, and various fragments. Since the young postlarvae are capable of feeding, and since one of those had fed abundantly, the frequency of empty stomachs in this group may indicate a soft-bodied diet, regurgitation when captured or preserved, or unusually efficient digestive processes. The large quantity of food ingested by many of these fish tends to strengthen the latter suggestion.

Amphipods, euphausids, shrimp and other decapods, and fish eggs were also found. As previously noted, one specimen 14.0 mm standard length had swallowed another *Histrio* just half its own size; in a second instance, a 19.0 mm specimen was found to contain not only a fish *(Psenes)* measuring 11.5 mm standard length, but also five euphausids, one fish egg, and a copepod.

Vertical Distribution of the Young. All specimens larger than 9.0 mm standard length were collected in surface waters and almost invariably from drifting weed. Smaller postlarvae in the series studied were collected in closing nets from the surface down to 600 meters. The author believes that records of young postlarval *Histrio* from such depths may be misleading. Since such larvae are equipped with an apparent flotation mechanism and are probably rather poor swimmers, their recorded occurrence at considerable depths may reflect improper closing of collecting nets or capture while the nets were being lowered. It is also possible that nonviable larvae drift down to deeper waters and may be captured there. However, it must be noted that nine out of seventeen postlarvae smaller than 9.0 mm standard length for which depth data were available were found at depths of 100 meters or more. There was no depth given for the remaining ten postlarvae in the 1.9-9.0 mm size range. The question of vertical migration of fish

TABLE 7

Histrio histrio (LINNAEUS). STOMACH CONTENTS OF SPECIMENS STUDIED

Station	Standard Length	Stomach Contents
SL 22 C-6	1.9	empty
SL 44 B-1	2.0	empty
SL 17 B-4	2.1	3 larval fish, 1 copepod, 1 medusa, fragments
SL 29 B-4	2.4	empty
SL 42 A-4	2.5	empty
SL 19 A-4	2.5	empty
SL 11 E-2	2.6	fragments
NG 11 A-3	2.6	1 larval fish, fragments
SL 19 D-8	2.6	empty
SL 17 B-5	2.7	1 amphipod, 1 fish egg
SL 10 B-2	2.7	fragments
SL 19 B-8	2.7	empty
SL 42 A-1	2.9	empty
SL 4 A	2.9	empty
NG 11 A-3	3.1	empty
SL 30 A-6	3.3	empty
SL 11 A-5	3.3	empty
SL 17 D-1	3.4	fragments
NG 11 A-4	3.5	empty
SL 45 B-6	3.6	empty
SL 18 C-7	3.6	empty
SL 43 B-2	3.9	empty
NG 39 B	4.0	1 larval fish, fragments
SL 28 B-0	4.1	fragments
SL 23 D-5	4.3	1 copepod
SL 26 A-3	4.4	empty
SL 37 B-2	5.0	empty
Supl. 75	9.0	1 amphipod
FR 34	9.5	fragments
Yuc. Sta. 58	10.0	1 fish egg, fragments
Supl. 46	10.1	1 shrimp
Supl. 79	10.7	1 larval fish, 1 fish egg, fragments
Supl. 76	11.5	empty
Supl. 2	11.5	1 fish, crustacean fragments
Supl. 2	11.5	2 shrimp, 1 decapod (crab?) fragment, 20 hatching larval fish (0.5 x 1.0 mm)
Supl. 79	12.5	1 medusa, 1 crustacean
Yuc. Sta. 10	14.0	1 euphausid, fragments
Yuc. Sta. 10	14.0	1 *Histrio histrio* (ca. 7.0 mm standard length; dorsal spines I, II discrete; III appearing)
NG 22 B	14.9	6 copepods, 1 crab
Supl. 2	15.2	1 euphausid, 1 monocanthid fish
Yuc. Sta. 10	15.2	1 larval fish, fragments
IS 2	15.5	crustacean fragments
Supl. 2	17.0	1 fish egg, fragments
Supl. 28	19.0	1 fish (*Psenes*, ca. 11.5 mm standard length), 5 euphausids, 1 fish egg, 1 copepod

larvae merits further study, and such investigation may prove the significance of the present data on young *Histrio* postlarvae.

No evidence of diurnal migration was found in the nineteen larvae for which data on depth and time of day were available.

Function of the Inflated Integument. The possible origin and significance of the separated integument found in many pelagic fish larvae was discussed by Shelbourne (1956), and further discussion of his theory and exceptions to it were afforded by Orton (1957). Shelbourne's paper related the development of large subdermal spaces to the pelagic condition, indicating that such spaces might be a functional solution to the problems of water loss and maintenance of buoyancy. The accumulation of yolk-diluent under the integument during larval development was regarded as meeting osmotic and buoyancy requirements, as well as providing a direct method of yolk-appropriation for developing tissues. Rasquin (1958) discussed the application of this theory to *Antennarius* and *Histrio,* and pointed out specialized cells in the gill membranes and peculiar ectodermal cells in the prolarvae of these species. Such cells may prove to excrete salt, thus performing osmotic work at a time when the kidneys are poorly developed. A survey of pertinent works was given in the same paper.

Further histological and physiological studies on *Histrio* hinge upon maintaining these larvae in captivity for longer periods than has so far proved possible, or upon collecting these larvae in quantity. Present evidence indicates that the so-called bubble of young postlarval *Histrio,* while more highly developed than in other larval fish described, operates in the manner described by Shelbourne; that is, it functions in osmo-regulation, buoyancy and food transport.

Discussion

This paper traces postlarval development in *Histrio histrio* obtained from Florida Current waters. Reference is made to papers by Mosher (1954) and Rasquin (1958) who reported on prolarval development in aquarium-raised *Histrio* larvae. Thus, a developmental sequence from prolarva to juvenile can be constructed with one important interruption, the transition from pro- to postlarva. All aquarium prolarvae died at the time of yolk-sac absorption, and specimens in this stage of development were not available to the writer.

Developmental tables from fertilization of the egg till death of the larva were given by both Mosher and Rasquin. The rate of development of the larvae differed somewhat in these two studies, but was ex-

plained by differences in the temperature at which they were raised. Prolarvae studied by Padmanabhan (1957; in Rasquin, 1958) developed much faster than those in the other two groups, but no temperatures were given. Larvae in all three cases died before the initially large subdermal spaces expanded still further to form the integumentary "bubble." The latest prolarva studied by Rasquin (1958) showed anlagen of the first two dorsal spines and differentiation of the caudal fin, but the median fins were undifferentiated and the pelvics had not yet appeared. Abnormalities heralding death were evident. The youngest postlarva studied by the present author had a fully developed "envelope," three dorsal spines, and all fins at least partially formed.

The writer has examined eggs and prolarvae collected by Rasquin and has compared them with the above-mentioned developmental schedules and the accompanying plates. The oldest prolarvae were found to average about 1.6 mm in total length. Death at this stage was attributed by Mosher (1954) to lack of suitable food when the yolk was used up. The writer feels, however, that such an explanation is oversimplified, in light of the following observations.

Rate of development of the aquarium-raised prolarvae seemed to be unreasonably slow in the last several days of life. Furthermore, a comparison of the largest prolarval specimen (1.6 mm total length) to the smallest postlarval specimen (about 3.0 mm total length; 2.0 mm standard length) shows the latter to be far more advanced than the observed rate of development in the prolarvae would lead one to expect. A metamorphosis seems to have occurred over an interval of 1.0-1.5 mm of axial growth. If, however, the aquarium prolarvae did grow abnormally slowly, a smoother transition from pro- to postlarva is indicated.

It seems likely that certain changes in *Histrio* larvae do not take place in a normal fashion in aquaria, and may be reflected in retarded growth as well as outright abnormality. Perhaps the envelope, undeveloped in late prolarvae but prominent in early postlarvae, did not develop properly under aquarium conditions. Requirements for oxygen, turbulence, pressure, or other factors may not have been adequately met. Rasquin (1958) agreed with Mosher (1954) that the late prolarvae did not obtain proper nourishment, but pointed out that the dying larvae also showed signs of desiccation. She cited osmoregulatory difficulties, gas disease from super-saturation of the water or too low a pressure, and inconstant temperature as possible contributors to larval deaths.

All organ systems must begin to function independently when the yolk-sac is absorbed. Subsequent failure of the larva to nourish itself may reflect improper or inadequate diet, but may also indicate prior abnormal development, so that life independent of the yolk-sac cannot be sustained.

The single specifically larval character in *Histrio histrio* is the "bubble." Aside from that, development is direct, and even the "bubble" is a difference in degree only. No other character indicates a dramatic change or metamorphosis during larval development. The writer believes that, while a spectacular expansion of the integument in late prolarval life is possible, it is mechanically unlikely. Probably, the integument steadily separates from the body while the yolk-sac resorbs and the fins and other organs attain the postlarval level of development. Desiccation of late prolarvae may be related to failure of the "bubble" to expand, for reasons intrinsic to usual aquarium conditions.

Marine fish larvae are often difficult to raise in aquaria, and, while the associated problems may be resolved in the future, the present question of normal development in *Histrio* at yolk-sac resorption may be more readily answered by further collection in the field. *Histrio* postlarvae, juveniles and adults are fairly abundant in Florida waters, and presumably the prolarvae as well. Collection and recognition of this transitional stage will provide the missing link in the larval development of *Histrio histrio*.

Present data do not yield the length of time it takes a fertilized *Histrio* ovum in the open sea to develop into a juvenile, nor the normal duration of prolarval and postlarval existence. Different water temperatures in the year-round spawning cycle undoubtedly affect these intervals. Neither larval nor adult life span need be correlated with the life span of pelagic *Sargassum*, however, since this has been shown to be exceedingly long (Parr, 1939).

The food of postlarval and juvenile *Histrio* is unlike that of the majority of larval fish whose diet is known. Most studies indicate that larval fishes subsist primarily on copepods, and while copepods were found in the stomachs of several of the *Histrio* studied, they did not constitute a main element in the diet. However, the observed difference is probably one of degree, since *Histrio* is capable of ingesting larger prey at a younger stage than are most other fish. This factor is certainly related to the large size of the mouth and the great distensibility of the stomach.

Histrio probably breeds in the Florida Current area during most if not all of the year. More observations are needed to establish whether or not temperatures in the Florida Current and adjacent waters at times fall below a minimum spawning threshold for *Histrio*. Determination of the minimum spawning temperature would permit more precise definition of the distribution pattern of this fish.

Ecological Notes

The Sargassum fish, *Histrio histrio,* is found in floating weed in the North Atlantic Ocean, in the Pacific, and in the Indian Ocean. In the Atlantic Ocean *Histrio histrio* is recorded from West African waters off Senegal (Cadenat, 1950), and from the Caribbean, the Gulf of Mexico, and the Sargasso Sea. Stragglers are swept northward in the Gulf Stream system as far as Cape Cod and beyond, but these cannot be considered to contribute further to the population, since neither *Histrio* nor its pelagic substrate, the *Sargassum* weed, can live and reproduce in waters whose temperature falls much below 18°C (Winge, 1923). The main Atlantic population is found in the great eddy of the Sargasso Sea, east of the Greater Antilles and the Bahamas and north to Bermuda; the largest individuals are also collected there.

In the Pacific Ocean *Histrio* is recorded throughout the South Sea Islands, from Australia and Indonesia northward to Japan, and more recently from the Galápagos and Hawaiian Islands (Schultz, 1957). In the Indian Ocean specimens have been taken from the Bay of Bengal and Ceylon and from the coastal waters of Africa.

Since *Histrio* is a monotypic genus, one is led to speculate on its wide distribution, especially since many other members of the *Sargassum* complex are specifically or generically the same in both the Atlantic and Pacific Oceans. Parallel evolution alone is a scarcely sufficient explanation. Was floating weed with its characteristic fauna swept from the Caribbean to the Pacific at the time of Central American submergences, and thence with the prevailing winds and currents to the South Seas? It seems possible; and, thereafter, the free gene-flow in a wave-borne community would theoretically discourage the formation of radically different species or subspecies, although certain local forms might be added to the complex. In short, given the basic premise of Atlantic-to-Pacific transfer, evolution of all members of the *Sargassum* complex would be likely to proceed relatively slowly and within the limits imposed by the specific habitat. However, while such a hypothesis may be advanced, it is difficult to substantiate.

There is no fossil record whatever of the family, and indeed, the entire order is represented geologically solely by a fossil lophioid from the lower Eocene. This might be expected when one considers not only the relative scarcity of marine vertebrate fossils, but also the characteristic habitats of the pediculate families. Fossil preservation of the lophioids or the antennariids other than *Histrio* would be much more likely than such preservation of either *Histrio* or the ceratioids.

Histrio is of especial biologic interest as a member of the remarkable pelagic community associated with floating *Sargassum* weed. This community has many characteristics of a littoral fauna, and may be described as a pseudobenthos adrift on the high seas. However, while the *Sargassum* fauna is undoubtedly originally derived from coastal forms, there is strong evidence that the majority of the population is not composed of accidentally displaced animals, but has lived for generations in a drifting state. Parr (1939) showed that 89 to 99 per cent of the weed in the Sargasso Sea is wholly pelagic and lives and reproduces vegetatively in the open ocean for tens or even hundreds of years. He further showed that this healthy weed is seldom if ever so overburdened by epizoans as to sink. Woodcock (1950) experimentally confirmed the enormous buoyancy of the weed, thus further supporting the modern belief that floating weed in fact constitutes a quite stable and self-perpetuating environment, and not an accidental and short-lived phenomenon as was formerly held to be the case. The import of Parr's work on the understanding of the *Sargassum* community is obviously great. It has been seen that a self-sustaining floating community on the high seas is feasible; and that such a community, refreshed now and again by adaptable emigrants from the coast and amplified by those forms found on all oceanic drift matter, can reproduce and evolve for generations quite independently of the mainland. This theory offers a valid explanation for the observed dwarfing of much of the *Sargassum* fauna. For instance, the isopod *Ianira minuta,* which attains a maximum length of two millimeters, is regarded as a separate species from the littoral *Ianira maculosa,* which grows to ten millimeters (Ekman, 1953).

Dwarfing is not the only interesting feature of the *Sargassum* fauna. Coloration and pattern of these animals is often strikingly similar to the weed and its encrustations, and many forms have weed-like appendages. *Histrio* is a prime example of this mimicry.

Curious faunal parallels exist between certain Sargasso Sea and Mediterranean animals; for example, the annelid *Alciope contrainii*

and the copepod *Copilia mediterranea* are known only from these two regions (Ekman, 1953). A point of taxonomic interest is the use of certain hydroids found on *Sargassum* in the specific classification of the weed itself. This practice was first found useful by Winge (1923), and has since been further developed by Burkenroad (in Parr, 1939). Burkenroad lists seven hydroids as "dominants"; that is, as forms exhibiting specificity to one or more varieties of *Sargassum*. These dominant hydroids generally occur in extensive colonies over distal (young) growth. Other hydroids and bryozoans constitute a "subfauna" which may occur with any dominant; the subfauna is most frequently found in patchy growths on the inner (older) parts of the plant.

Ekman (1953) divided the animals found on *Sargassum* into three general categories as follows: (1) sessile organisms, such as bryozoans and barnacles; (2) clinging types, such as the decapod crustaceans; and (3) free-swimming forms, such as *Histrio* and the pipefish. It is debatable whether *Histrio* should be classified as free-swimming or as clinging, since the fish, while capable of paddling about or darting by jet-propulsion, nevertheless is generally found resting or clambering about in its private clump of weed. A fourth group, termed associated organisms, might be added to Ekman's above-listed three, although in some respects the categories overlap. Such associated organisms may be subdivided into (1) those drifting invertebrate inhabitants of warm seas, such as the siphonophores *Physalia* and *Velella* and the gastropod *Ianthina* (*Janthina*), which by their nature are swept by wind and current into oceanic eddies, as is the weed; and (2) those forms (primarily fish) which seek shelter or food in the weed, or lay their eggs upon it (certain exocoetids), or whose larvae are typically found in the surface layers together with the weed (as, eel leptocephali), but whose adults are independent of the weed and not morphologically adapted to it.

Hjort (1912; in Murray and Hjort, 1912) discussed types of fishes found in warm, light, and thin oceanic waters. They stated that considerations of specific gravity and viscosity would favor those animals which have increased their buoyancy by the aid of light substances (fats, water); or which are reduced in size and thus have a higher surface/volume ratio; or which have special flotation mechanisms. Thus they divided fishes found in the surface layers of such waters into three groups: (1) the minute Scopelidae and small young fish, the latter found especially at night; (2) the larger, oily fish like the

sunfish *Mola,* which has a blubber layer under the skin; and (3) those species which live near solid floating objects, as does *Histrio.*

Representatives of the above-mentioned groups of animals which are more or less closely associated with pelagic weed are listed in Table 8.

TABLE 8

ANIMALS COMMONLY ASSOCIATED WITH *Sargassum* WEED

CINIDARIA: Hydroids *Plumularia obliqua, Aglaophenia latecerinata, Desmocyphus pumilus, Clytia, Laomedea (Obelia), Sertularia, Gemmaria costata, Halecium nanum, Monotheca margaritta.* Siphonophores *Physalia, Velella.* Anemone *Anemonia sargassensis.*
PLATYHELMINTHES: Polyclad Turbellarians *Stylochus mertensi, Stylochus pellucidus.*
ANNELIDA: Polychaetes *Spirorbis, Alciope contrainii.*
ARTHROPODA: Pycnogonids *Endeis spinosa, Tanystylum orbiculare.* Crustaceans: Barnacles *Lepas anserifera, Lepas pectinata, Lepas anatifera, Conchoderma virgatum.* Cladoceran *Evadne spinifera.* Amphipods *Amphithoe pelagica, Vibilia pelagica.* Isopods *Idotea metallica, Idotea whymperi, Bopyrus squillarum, Bopyroides latreuticola* (*Bopyrus* and *Bopyroides* parasitic on decapods), *Ianira minuta.* Copepod *Copilia mediterranea.* Decapods: Peneid prawn *Sergestes oculatus.* Caridean shrimps *Palaemon pelagicus, Palaemon fucorum, Palaemon natator, Leander tenuicornis, Hippolyte tenuirostris, Hippolyte ensiferus, Virbius acuminatus, Alpheus* (snapping shrimp), *Latreutes ensiferus.* Crabs *Planes minutus* (grapsoid), *Neptunus sayi* (portunid).
MOLLUSCA: Pteropod *Creseis spinifera.* Gastropods: *Ianthina (Janthina)* (pelagic). Nudibranch *Scyllaea pelagica* (carnivorous). Aeolid nudibranchs *Aeolidella occidentalis, Spurilla sargassicola, Fiona marina, Cuthona pumilio, Glaucus atlanticus, Doto pygmaea.* Sea hare *Tethys protea.* Cephadopod *Onychia caribaea* (squid).
BRYOZOA: Ectoprocts *Membranipora tuberculata, Flustra tuberculata, Flustra peregrina.*
PROTOCHORDATA: Ascidian tunicate *Diplosoma.*
PISCES: *Histrio histrio, Syngnathus pelagicus* (pipefish), *Dactylopteris volitans* (flying gurnard), *Hippocampus ramulosus* (seahorse), *Monacanthus* (filefish), *Mola,* (sunfish); flying fish, needlefish, and halfbeaks; carangids; various leptocephali.

SUMMARY

1. The fishes of the family Antennariidae are generally discussed. Previous work leading to the identification of *Histrio* larvae is indicated.
2. A series of forty-four postlarval and juvenile *Histrio histrio* ranging in size from 1.9-19.0 mm standard length is described and representative specimens are figured. Data on food, vertical distribution and seasonal occurrence of the young are given.
3. Indices and graphs show the body proportions of these fishes. All

body proportions were found to vary in a similar fashion. Depth was an unreliable measurement, due to the distensibility of the fish.

4. A discussion of the development of *Histrio* larvae is presented.
5. Ecological factors of importance to *Histrio* are mentioned. Worldwide and local distributions of *Histrio* are summarized. The *Sargassum* complex is generally discussed.

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STUDIES ON FISHES OF THE FAMILY OPHIDIIDAE.—V. *LEPOPHIDIUM PHEROMYSTAX*, A NEW ATLANTIC SPECIES ALLIED TO *LEPOPHIDIUM JEANNAE* FOWLER.[1]

C. RICHARD ROBINS
The Marine Laboratory, University of Miami

ABSTRACT

A new species of *Lepophidium* (Pisces: Ophidiidae) is described from the South American coast off the Guianas. A single specimen of the species, from Campeche Bay, Mexico, differs somewhat from the South American population. Adults of *Lepophidium jeannae* Fowler are described for the first time. The new species is closely allied to *L. jeannae* and differences between the two are discussed.

INTRODUCTION AND ACKNOWLEDGMENTS

Recent exploratory cruises of the United States Fish and Wildlife Service vessel OREGON along the northern coast of South America and of the COQUETTE around Surinam have yielded important collections of fishes from a previously poorly sampled area. Among the many new species of fishes encountered is the species of *Lepophidium* described below. In addition, similar efforts in the Gulf of Mexico by the OREGON and COMBAT have yielded for the first time the adults of *Lepophidium jeannae* Fowler. This species, recently discussed by Robins (1959a: 366-367), is now described.

The efforts of Harvey R. Bullis of the Fish and Wildlife Service to obtain and contribute ophidiids to the writer's continuing studies of the family are appreciated. In particular, I wish to thank Giles W. Mead and his assistant James C. Tyler for lending much of the material reported on here and for securing the radiographs upon which the counts of vertebrae are based. Additional material was provided by Loren P. Woods of the Chicago Natural History Museum, John C. Briggs and Daniel M. Cohen of the University of Florida and Ernest A. Lachner, Leonard P. Schultz and Robert H. Kanazawa of the United States National Museum. Walter R. Courtenay, Jr. provided the photographs and Jo Ann Rose processed the data and prepared the illustration of the head-pore arrangement. This study was supported by a grant-in-aid (NSFG-7116) from the National Science Foundation and constitutes a technical report to that organization.

[1]Contribution No. 262 from The Marine Laboratory, University of Miami.

In the material examined sections, the number of specimens and their ranges in standard length are indicated in parentheses. The following abbreviations are employed: CNHM (Chicago Natural History Museum), UMML (University of Miami Marine Laboratory), UF (University of Florida), ANSP (Academy of Natural Sciences of Philadelphia), MCZ (Museum of Comparative Zoology, Harvard University), and UMMZ (University of Michigan Museum of Zoology).

Lepophidium pheromystax, new species

Figs. 1-2, Tables 1-2

Holotype. USNM 185737, a female, 173 mm in standard length, 07°55′N, 57°25′W, 50 fathoms, M/V OREGON station 2001, Nov. 5, 1957.

Paratypes. USNM 185739 (1, 160) and CNHM 64502 (1, 155) taken with the holotype. UMML 3990 (4, 150-199) 07°18′N, 56°49′W, 30-33 fathoms, M/V OREGON station 2262, Sept. 1, 1958. USNM 185740 (1, 164) and CNHM 64501 (1, 157) 07°55′N, 57°34′W, 43 fathoms, M/V OREGON station 1999, Nov. 5, 1957. CNHM 64499 (5, 145-168), UMML 5049 (4, 161-200) and UMMZ 177299 (4, 152-198), 07°55′N, 57°30′W, 45 fathoms, M/V OREGON station 2000, Nov. 5, 1957. CNHM 64519 (1, 116) 06°15′N, 52°35′W, 37 fathoms, M/V OREGON station 2318, Sept. 14, 1958. CNHM 64514 (6, 108-176), 07°38′N, 57°34′W, 26-27 fathoms, M/V OREGON station 2250, Aug. 31, 1958. CNHM 64513 (5, 106-170) 07°40′N, 57°34′W, 27-30 fathoms, M/V OREGON station 2249, Aug. 31, 1958. USNM 185738 (1, 218) 04°02′N, 50° 20′W, 50 fathoms, M/V OREGON station 2054, Nov. 14, 1957. USNM 185742 (6, 71-95) 06°49′N, 55°36′W, 26 fathoms, M/V COQUETTE station 321, July 20, 1957. USNM 185743 (1, 99) 06°47′N, 55°40′W, 25 fathoms, M/V COQUETTE station 283, June 26, 1957. USNM 185741 (1, 179) 06°50′N, 55°24′W, 29 fathoms, M/V COQUETTE station 332, July 20, 1957. ANSP 89346 (1, 112) 05°45′N, 52°18′W, 33 fathoms, M/V OREGON station 2311, Sept. 12, 1958. MCZ 40422 (3, 145-154), ANSP 89347 (2, 96-190) and UMML 5052 (3, 115-166), 07°20′N, 56°49′W, 33 fathoms, M/V OREGON station 2261, Sept. 1, 1958.

Additional material. UMML 5050 (3, 98-119) M/V OREGON cruise 53 (stations 2207-2356), exact station unknown. CNHM 64521 (1, 154) Surinam, M/V COQUETTE. CNHM 64515 (1, 85), 07°20′N, 56°49′W, 33 fathoms, M/V OREGON station 2261, Sept. 1, 1958. UMML 5051 (1, 145) 18°43′N, 93°29′W, 25 fathoms, M/V OREGON station 1059, May 16, 1954, ANSP 89348 (1, 124) 05°54′N, 52°22′W, 31-33 fathoms, M/V OREGON station 2298, Sept. 11, 1958.

Diagnosis. A *Lepophidium* with large, conspicuous dark spots on the body. Margin of dorsal fin alternately dark and pale, anal-fin margin dark. Caudal fin pale centrally, its upper and lower thirds nearly black. Dorsal- and anal-fin rays moderate in number usually 127-130 and 104-109 respectively. Caudal rays 9, pectoral rays usually 21, pyloric caeca usually 3, gill rakers 8, infrequently 9, vertebrae usually 71.

Description. Fin-ray counts and a summary of other meristic features are presented in Table 1. Morphometric data are given in Table 2.

TABLE 1

MERISTIC DATA FOR *Lepophidium pheromystax*, N. SP. AND *L. jeannae* FOWLER

Species	Dorsal Rays														
	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139
L. pheromystax	1	2	5	14*	10	7†	1	1	—	—	—	—	—	—	—
L. jeannae	—	—	—	—	—	—	—	—	—	—	3*	1	1	1	1

	Anal Rays													
	104	105	106	107	108	109	110	111	112	113	114	115	116	
L. pheromystax	5	4	14*†	6	7	4	1	—	—	—	—	—	—	
L. jeannae	—	—	—	—	—	—	—	—	1	1	3*	1	1	

	Pectoral Rays			Gill Rakers		Vertebrae								
						Precaudal		Caudal						
	20	21	22	8	9	14	15	54	55	56	57	58	59	60
L. pheromystax	12	69*†	5†	36†	9*	1	19*†	1	3	11*	5†	—	—	—
L. jeannae	2	10	—	3	4*	1	4	—	—	—	—	—	3	2

	Total Vertebrae							Pyloric Caeca			
	69	70	71	72	73	74	75	1	2	3	4
L. pheromystax	2	2	11*	5†	—	—	—	1	1	34*†	1
L. jeannae	—	—	—	—	—	3	2	—	—	5	—

* holotype
† Campeche specimen

Measurements analyzed in Table 2 are defined below. Numbers of branchiostegal rays were checked on those specimens which were preserved with the gill membrane spread. No departure from the usual 7 per side was noted in this character which appears constant or nearly so for the family. Likewise the caudal-ray count was constantly nine for 41 specimens. Two rudimentary gill rakers were on the upper arch and four developed rakers were on the lower arch of all specimens examined. Below the developed rakers on the lower arch are two and occasionally three rudimentary rakers. Thus, the total count is 8, seldom 9. The shift from developed to rudimentary rakers is abrupt. Such a pattern of gill-raker development is like that already described and figured for *L. jeannae* Fowler by Robins (1959a: 367, fig. 1f). Except for three specimens there were three pyloric caeca, two ventrally and one dorsally. Variation, as recorded in Table 1, involves the ventral caeca only. Variation in vertebral numbers is associated largely with the caudal vertebrae. Separation of the vertebral elements into precaudal and caudal sections is easily determined on the radiographs. The first caudal vertebrae has a closed arch, a condition not approximated by the last precaudal vertebra. Also the dorsal aorta ascends abruptly at the level of the anterior margin of the first caudal vertebra. Numbers of vertebrae are recorded in Table 1.

No effort was made to secure an estimate of variability of numbers of scales. A few counts were made which indicate a scale formula of 11-194-27 but they are at best approximate; number of scales is apt to be quite variable if analogy may be drawn from after groups of fine-scaled fishes.

The head is scaled as far forward as the anterior interorbital region above, and the orbite on the side. The maxillae and the branchiostegal membranes are naked.

Dentition is apparently similar throughout the genus. The vomer and palatine patches of *pheromystax* are about as diagrammed for *L. staurophor* (Robins, 1959a: fig. 1g). The rather narrow patches indicated for *L. jeannae* (Robins 1959a: fig. 1h) reflects a juvenile condition. The teeth on the premaxillae and dentary are arranged in rows of which the outermost is best developed. Surrounding the premaxillary and dentary teeth are numerous papillae. All teeth on these patches are depressible. Vomerine and palatine teeth are small and blunt forming a delicate molar plate. These teeth are short and not hinged.

The rostral spine is well developed and reaches the snout tip in

most specimens; in some it projects forward beyond the snout. The flattened opercular spine is also present as in all members of the genus.

Pelvic-ray length, often used to characterize cusk eels, is variable. Generally the shorter division is about two-thirds the length of the longer (see Table 2). Also the longer usually, but not always, exceeds slightly the length of the pectoral fin.

The lateralis system consists of a lateral, supraorbital, infraorbital and preoperculomandibular canal on each side of the head and a single supratemporal canal above. Figure 2 diagrams in black the canal system of *L. pheromystax*. The supratemporal canal connects the two lateral canals just forward of the junction of the lateral and preoperculomandibular canals. Three pores, one median, open from side canals projecting caudad from the supratemporal canal. Only one pore, placed just above the middle of the opercle, opens on the lateral canal. The supraorbital canal opens through four pores, the first on a medially projecting side canal above the posterior half of the eye, the second, a median coronal pore, the third just behind and above the anterior nostril and the last under the anterior nostril opening caudad into the subnasal depression. The infraorbital canal has eight pores, three in a vertical row behind the eye, the third also being the first in the row along the suborbital rim, on which the five additional pores open, the last at the subnasal depression. Each preoperculomandibular canal has eight pores, one on a side canal just below the junction with the lateral canal, the second on the lower part of the operculum, the third opening off the opercular ring and the fourth behind the corner of the mouth. The remaining four pores are near the tip of the jaw, two opening outwardly and two being nearly concealed in the depression on the inside of the ramus. The posterior nostril is nearly on the anterior rim of the orbit just below its mid-point. The anterior nostril is far forward on the snout tip and opens from a short tube. Unlike *L. kallion* Robins the snout tip is not decorated although it is variously grooved, and is incised at the midline.

Coloration alone will identify *L. pheromystax*. The background is yellowish-brown in preservative, somewhat duskier above than below, and palest, almost whitish, on the chest and chin. Superimposed on the background are numerous spots, the larger of which approximate the eye in size, especially in juveniles. The upper row occupies the area from the dorsal fin to and somewhat below the lateral line. Approximately 15 spots are in this row. Those extending below the lateral line are interrupted by the pale-colored lateral-line. Between these

FIGURE 1. a, *Lepophidium jeannae* Fowler, UMML 2225, adult male, 196 mm in standard length, M/V COMBAT station No. 519. b, *Lepophidium pheromystax*, holotype, USNM 185737, female, 173 mm in standard length, M/V OREGON station No. 2001. c, *Lepophidium pheromystax*, paratype, USNM 185742, juvenile, 90 mm in standard length, M/V COQUETTE station No. 321.

large spots are smaller spots along the dorsal-fin base and extending onto the basal portion of the fin membrane. Spots from both sides tend to run together on the mid-dorsal line to form irregular saddles or

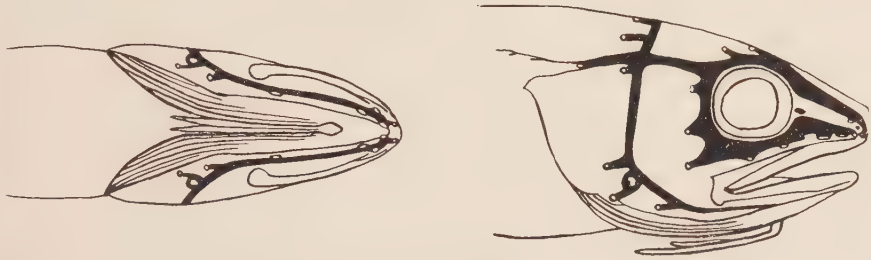

FIGURE 2. Development of the cephalic lateralis system in *Lepophidium pheromystax*. Canals are indicated in black.

hour-glass markings. The lower row of spots extends along the mid-side from just above and behind the pectoral fin to the caudal base. Generally the row alternates between large and small spots. This pattern may be best seen in Figure 1, b and c.

Except for two features the head is rather plain, darker on the portion above the lateral canals and eyes than below. A cluster of melanophores on the inner surface of the opercle about at its upper junction with the preopercle shows through as a black "ear" spot which is characteristic. On the lower half of the maxillae, a streak of melanophores forms an equally characteristic "mustache." The skin above the rostral spine is also somewhat darker than the surrounding area.

The dorsal fin is conspicuously spotted with black. The spots extend downward from the margin more than half the distance to the fin base as a series of U-shaped black areas. Apparently the number of dark areas increases with size. There are 19 on the holotype the last of which extends onto the caudal fin. Ill-defined and smaller dusky areas occur between and slightly below these black spots. The anal fin is dusky throughout with a black border. Basically the caudal fin is pale but the dorsal- and anal-fin pattern extends onto its upper and lower third so that in most specimens the fin is tricolored, black above and below and pale centrally. The pectoral and pelvic fins are pale.

The oral cavity (except for the dusky upper pharyngeal area), the gill chamber (except for the "ear" mark noted above), the gill arches and the branchiostegal membranes are pale. The peritoneum is pale or even silvery. The stomach and hind gut are pale but the esophagus

is black, the contrast at the stomach being sharply defined.

L. pheromystax, like other species of its genus, has a simple gas bladder, a tapered sac, somewhat thick-walled, and without tubes or openings apart from the ventral rete.

Explanation of Table 2. Most measurements treated in Table 2 are standard. A few require definition. Body depth is measured at three

TABLE 2

FREQUENCY DISTRIBUTIONS OF BODY MEASUREMENTS OF *Lepophidium pheromystax,* N. SP. AND *L. jeannae* FOWLER, EXPRESSED AS PERCENTAGES OF STANDARD LENGTH (* INDICATES HOLOTYPE, † CAMPECHE SPECIMEN).

Species	Head-Length				Predorsal Distance				Preanal (fin) Distance				
	19	20	21	22	20	21	22	23	35	36	37	38	39	40
L. pheromystax	2	9	6†	11*	1	5	15*†	6	2	3	8	8†	4*	2
L. jeannae	—	—	5	—	—	1	3	1	—	2	—	2	1	—

Species	Postorbital Length					Body Depth (1)				Body Depth (2)				Body Depth (3)		
	9	10	11	12		11	12	13		11	12	13	14	10	11	12
L. pheromystax	1	3	14†	9*		3	12†	8*		4	9*	10	1	5†	14	6*
L. jeannae	—	—	1	4		1	2	1		—	3	1	1	5	—	—

Species	Pectoral-fin Length				Pelvic-fin Length											
	7	8	9	10	Outer Ray							Inner Ray				
					6	7	8	9	10	11		5	6	7	8	
L. pheromystax	2	16*	7†	1	1	5	5	8*	7†	—		2	11*†	10	3	
L. jeannae	—	3	—	2	—	—	1	2	1	1		—	2	2	1	

Species	Snout tip to Occiput				Caudal-fin Length			Snout Length				Maxillary Length			Orbit Diameter			
	13	14	15		3	4	5	4	5		8	9	10		5	6	7	
L. pheromystax	2	17*†	8		2	21*	1	22*†	4		1	9†	18*		—	23*†	5	
L. jeannae	—	3	2		1	3	1	—	5		—	2	3		5	—	—	

Species	Bony Interorbit			Length of Lateral Line										
	3	4	5	87	88	89	90	91	92	93	94	95	96	
L. pheromystax	21†	5*	—	1	2	1	5*	2	8	--	3†	1	—	
L. jeannae	2	2	1	—	—	—	1	1	—	—	—	—	1	

places: (1) at the occiput, (2) at the dorsal-fin origin and (3) at the anal-fin origin. Orbit diameter is the horizontal diameter of the bony orbit. Maxillary length, really the upper jaw length, is measured from the anterior junction of the premaxillae to the posterior edge of the maxilla. Length of lateral line is the distance from the snout tip to the posterior terminus of the lateral line. In practice, the writer measures the distance from the posterior tip of the lateral line to the posterior edge of the hypural plate and subtracts the result from standard length to obtain the length of the lateral line. Snout length is the distance between the snout tip and the anterior edge of the bony orbit. Both branches of the pelvic ray are measured from their tips to the base of the pedicel that they share. All measurements were made with dial calipers. Measurements, in millimeters, of the holotype follow: Standard length—172.9; head length—37.7; predorsal distance—37.2; preanal distance—67.7; snout tip to occiput—24.3; body depth (1)—23.0, (2)—20.8, (3)—19.8; pectoral-fin length—14.1; pelvic-ray length—16.0, 11.0; caudal-fin length—6.8; length of lateral line—154.9; postorbital head length—20.6; diameter of bony orbit—10.4; bony interorbital distance—6.2, snout length—7.5; maxillary (upper jaw) length—17.4.

Biology. Specimens from which counts and measurements were taken were also sexed. As with most ophidiids, females outnumber males about 4 or 5 to 1 in collections. One interesting exception was OREGON station 2250 where 5 of 6 specimens were males. No disparity was found when occurrence of sex was correlated with depth. *L. pheromystax* is a moderate sized species, seldom exceeding 190 mm in standard length (largest examined—218 mm). In some cusk eels the males are smaller but this is untrue in *pheromystax*. In fact the largest individual was a male. The disproportionate sex ratio, if not a real feature, must reflect different habits of the two.

Many specimens were mature or nearly so when collected. Females judged to be ripe or nearly so were 152 mm or longer but several as small as 112 mm had enlarged ovarian eggs. Males 144, 200 and 218 mm were thought to be in breeding condition. Mature specimens were collected at OREGON stations 1999, 2000, 2001, 2054, 2250, 2318.

Stomach analysis of trawl specimens often misleads the observer interested in determining food habits of a species, because of increased availability and catchability of other items in the trawl. Therefore only a few stomachs were examined. Numerous small crustaceans and an occasional small fish (Bothidae) were found.

Larger specimens may be expected anywhere in the depth range of the species (see below) but only two specimens shorter than 135 mm in standard length were taken deeper than 30 fathoms (one each at 33 and 37 fathoms). Few samples of small individuals (17 specimens, largely from 3 trawls) are available probably since escape of smaller individuals must be high. Therefore the tendency of smaller specimens to occur in the shallower portion of the species' distribution is a possibility only.

Distribution. *L. pheromystax* apparently ranges along the northern coast of South America from 4°02′N, 50°20′W off the northern tip of Brazil (Cabo d'Orange) to 7°55′N, 57°25′N north of Georgetown, British Guiana. All records but one fall within this belt along the coast of the Guianas. The exception is OREGON station 1059, at 18°43′N, 93°29′W in the Gulf of Campeche, Mexico. This specimen, discussed below in more detail, is only tentatively assigned to *pheromystax*. The vertical distribution of *pheromystax* is 25-50 fathoms.

Name. The specific name *"pheromystax"* is derived from the Greek words for "mustache" and "to bear" and refers to the dark streak on each maxilla.

Relationships. The relationships of *L. pheromystax* lie with *L. jeannae* and are discussed after the account of that species.

Lepophidium jeannae Fowler

Fig. 1, Tables 1-2

Lepophidium jeannae Fowler, 1941: 103, figs. 16-17 (original description, main channel south of Key West, Florida, 29 fathoms). Briggs, 1958: 292 (compiled). Robins, 1959a: 366-367, fig. 1f, h (discussion of holotype, meristic data corrected and supplemented).

Material examined. ANSP 69724 (1, 41) Holotype. UMML 1198 (1, 76) 24°45′-50′N, 82°10′-30′W, 16 fathoms (approx.), CRR-F-74, May 26, 1957. UMML 2225 (1, 196) 31°49′N, 79°31′W, 45 fathoms, M/V COMBAT station 519, Oct. 8, 1957, UMML 2370 (1, 235), 29°15′N, 80°13′W, 30 fathoms, M/V COMBAT station 334, June 1, 1957, UF 3642 (1, 238) 29°50′N, 86°30′W, 50 fathoms, M/V OREGON station 944, March 21, 1954, UF 5728 (2, 192-195) 21°09′N, 91°41′W, 28 fathoms, M/V OREGON station 1050, May 13, 1954.

Description. The above material is assigned to *L. jeannae* on the basis of agreement in all meristic features, the pattern of gill raker development, depth distribution and coloration of the dorsal fin. Meristic data are summarized in Table 1 and morphometric data are presented in Table 2 (see explanation above). The color pattern is freckled; numerous, irregularly scattered dusky spots are present over the upper two-thirds of the body including the top of the head forward to the

interorbital region. The head spots are not obvious. Generally the spots are small, much smaller than the pupil but some larger spots do occur above the lateral line on the posterior third of the body. The exposed portion of the maxillary is nearly black and a dark "ear" spot shows through as in *pheromystax*. Also the skin over the very prominent rostral spine is dark. The anal fin is dusky with a black border. The dorsal-fin margin is alternately black and pale, the black areas extending from the margin for a third or half the distance to the fin base as broad, shallow U-shaped marks. In the largest specimen the black areas greatly exceed in area the pale interspaces. In smaller specimens the pale areas are relatively wider. A row of dusky spots occurs along the basal half of the dorsal fin. The caudal fin is tricolored as in *pheromystax,* black above and below, pale centrally. The pectoral fin is pale. The oral cavity, branchial chamber (except for the ear spot), peritoneum, stomach and hind gut are pale. In contrast, the esophagus is black or very dark.

The pattern of gill-raker development has been diagrammed by Robins (1959a: fig. 1f). All specimens have two rudimentary rakers on the upper arm and four developed rakers on the lower arm. Two or three rudiments are present on the lower arm which cause the variation seen in this feature (Table 1).

Arrangement of palatine and vomerine teeth is as described above for *pheromystax* and shown by Robins (fig. 1h). The width of the patches increases with age. If *jeannae* differs in this feature from other species of the genus it is in having more rows of teeth on the patches. The rostral spine of *jeannae* is very well developed in large specimens and projects beyond the snout tip. Because of the swelling at the rostral spine combined with the long snout, the dorsal profile is somewhat concave above the anterior margin of the eye. This character is extreme in large individuals.

Arrangement of pores in the lateralis system of *jeannae* is precisely as described above for *pheromystax* (Fig. 2).

Scale rows were counted on several specimens. The scale formula is 13 or 14 - 189 - 27. No attempt was made to assess variation in scale number.

Distribution. The few localities from which specimens of *L. jeannae* are known are along the Atlantic Coast of the United States from off Savannah, Georgia, to Key West, Florida, and in the Gulf of Mexico from the Tortugas shrimp grounds, southeast of Pensacola, Florida, and in the northeastern section of Campeche Bay, Mexico. *L. jeannae*

is a shallow-water form ranging vertically from 16 to 50 fathoms.

Discussion

Lepophidium pheromystax and *L. jeannae* are closely allied allopatric species. Although entirely separable in numerous meristic features (Table 1), including numbers of vertebrae, many similarities are apparent. Color pattern although different is of similar nature. Both have a dark esophagus and share similar patterns of gill-rakers and head-pores. Both have three pyloric caeca. Both have similar vertical distributions.

Body proportions are essentially the same in both species (Table 2). The bony orbit is narrower and the snout is longer in *jeannae* but few data are available for that species.

The single specimen of *pheromystax* from Campeche Bay approaches *jeannae* in its smaller spotting (three rows). However in every feature in which the two species depart markedly, this specimen is assigned to *pheromystax*. Similarly, two specimens of *jeannae* from northern Campeche Bay showed no approach of *pheromystax* in their characters; in fact, they are extremes of *jeannae*.

Walters and Robins (in press) suggested that many species now restricted along the coast of the United States may have dispersed far to the south during glacial periods. Such a mechanism explains the differentiation of stocks subsequently isolated in southern regions during interglacial periods. This explanation may apply to the differentiation of *pheromystax* and *jeannae*. The occurrence of *jeannae* along the coast of the southeastern United States and in Campeche Bay occasions no surprise for many fishes are so distributed. Probably it will be found elsewhere on the northern and western periphery of the Gulf of Mexico. The occurrence of *pheromystax* in Campeche Bay and along the Guiana Coast is zoogeographically less plausible and indeed the color pattern of the Campeche specimen suggests some differentiation. Possibly additional material will reveal that the Campeche population merits nomenclatural recognition. This problem can not be solved now and the occurrence of *pheromystax* in Campeche Bay must be regarded as provisional.

L. marmoratum (Goode and Bean) is also spotted with dark but within the genus bears no close relation to *jeannae* or *pheromystax*. Some characteristics of *marmoratum* and its ally, *kallion*, were discussed by Robins (1959b: 6).

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AN ECOLOGICAL SURVEY OF THE MARINE INVERTEBRATES OF BIMINI, BAHAMAS, WITH A CONSIDERATION OF THEIR ZOOGEOGRAPHICAL RELATIONSHIPS[1]

GILBERT L. AND NANCY A. VOSS
The Marine Laboratory, University of Miami

ABSTRACT

The marine invertebrates of the shallow waters of Bimini, Bahamas, are listed, with descriptions of the habitats. Numbers and vertical distribution of the species occupying the intertidal zone and above are given, together with their plant and animal associates. The hydrographic conditions on the Great Bahama Bank are briefly discussed in relation to the distribution of the invertebrates. The fauna is compared with that of Soldier Key in the Florida Keys and the possible origins of the two faunas are discussed.

INTRODUCTION

In 1955, the authors published a paper on the invertebrate ecology of Soldier Key, the first of a proposed series on the ecology of various selected areas along the southeast Florida coast. While this study was in progress, the authors made a brief visit to the island of North Bimini in the Bahama Islands. The visit, extending from November 23 through November 28, 1953, presented the opportunity of studying in some detail an area similar to Soldier Key located on the opposite side of the Florida Straits. It was considered that such a survey might aid in solving some perplexing problems of zoogeography existing in this area. The original study has been supplemented by specimens and observations from other western Bahamian localities including the Cat Cays furnished by Marine Laboratory staff members. Among these should especially be noted Dr. C. Richard Robins who has also critically read the manuscript and Dr. Hilary B. Moore for his reading of the manuscript and his usual helpful suggestions.

The study was greatly aided by the generous and wholehearted assistance of Miss Joan Feil and Mr. Edmund Clancey, then of The Marine Laboratory, who accompanied the authors and who were in the field or working up data from early morning until after midnight each day.

The authors also wish to thank the authorities of the Lerner Marine

[1]Contribution No. 260 from The Marine Laboratory, University of Miami. This constitutes a technical report to the National Geographic Society.

Laboratory who placed the facilities of that institution at the disposal of the party, including collecting equipment, boats, lodging and laboratory space for the period of the visit. In particular they wish to thank Dr. Charles M. Breder, Jr., the director, for his kind interest in the work, his many helpful suggestions and the loan of tidal recordings for the zonal studies. In addition, they wish to thank Mr. Bishop, at that time the resident biologist, and his wife, and their staff for their kind aid and assistance.

Finally, the authors wish to thank the National Geographic Society for the financial assistance which made the study possible.

All identifications are the responsibility of the authors except where otherwise stated. Most identifications were made in the field but all specimens not immediately and positively recognized were collected and taken back to the Lerner Laboratory for further study. All specimens were finally taken to The Marine Laboratory, University of Miami, and were deposited in the Marine Museum of that institution.

Historical Resume[1]

The marine invertebrate life of the Bimini group is very poorly known and mention of invertebrates in the literature is very meager. Papers specifically dealing with the marine life of Bimini have appeared only since the founding of the Lerner Marine Laboratory in 1947.

Apparently the first paper to deal with Bimini was that of de Laubenfels (1949) on the sponges of the Western Bahamas. He listed 29 species and published a key to the 14 commonest ones. In 1950 Pearse studied the inhabitants of certain sponges at Bimini, listing the numbers of individuals and species, and compared them with those from similar studies carried out at the Dry Tortugas in the Florida Keys (Pearse, 1932). Again in 1951 he published a paper on the parasitic crustacea from fish and invertebrates of Bimini waters in which were recorded 26 copepods, 5 isopods and 3 cirripedia. In 1953 Andrew and Andrew published a paper on annelids and sipunculids and in 1956 Renaud reported upon collections of annelids collected both by her and by the authors during this study. Clarke (1955) published a description of a new species of mysid commensal upon actinians. A few observations on the mollusks were given by McGinty, 1948, and P. and L. McGinty, 1948.

[1]Since this paper was finished an important paper on the Bimini area by Norman, Imbrie, Purdy and Thurber (1959) has appeared. Much supporting evidence is found in this work and the general intertidal areas are enumerated, with a brief list of the associated fauna and flora.

An important paper on the distribution and ecology of madreporarian corals in Bimini waters was published in 1958 by Squires. While not agreeing entirely with the present findings, it is essential to an understanding of the ecology of Bimini and some of the factors at work. Under the direction of Dr. Norman D. Newell, a series of investigations are being carried out at Bimini on the bottom fauna, sedimentation and reef formation. Newell and Imbrie (1955) summarized some of these findings and gave diagrammatic profiles across the offshore slope of the island.

Hydrographic information is scarce but Turekian (1957) reported upon salinity transects at Bimini and the formation of water masses in the area. Earlier, C. L. Smith (1940) carried out hydrographic studies on the shallow banks back of Andros and the Berry Islands, some of which are pertinent to the present area.

In areas of calcium carbonate sediments, these sediments may play an important role in the ecology of the animals and plants. A paper of great importance is that by Ginsburg (1956) on the carbonate sediments of Florida Bay. This paper draws comparisons with the Bahama banks and summarizes effects and differences. The interstitial serval fauna was surveyed briefly by Renaud - Debyser (1955), Debouteville (1955) and Chappuis and Debouteville (1956).

No papers dealing with the algae of the area have come to the attention of the authors except for that by Howe (1904).

Topography

The Bimini Islands lie 60 miles due east of Miami on the eastern edge of the Straits of Florida. The group consists of three major islands, North, South and East Bimini, situated on the western edge of the Great Bahama Banks. These islands together form the somewhat equilateral triangle which embraces a small bay in which are scattered small islands (Fig. 1). With the exception of North Bimini, all are low and in the main covered with a growth of mangroves; red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia nitida*), and further towards the land the white mangrove (*Laguncularia racemosa*) and the buttonwood (*Conocarpus erectus*). North Bimini, the only island that projects above the sea to any extent, is about 30 feet above mean sea level at one point on the western side. The land is formed from aeolian limestone, and along the western side of North Bimini this forms abrupt cliffs, some of fair height, and in many places, especially at Paradise Point and the Bluffs, it forms thin sheets about 1 inch thick which often are separated and fallen away along

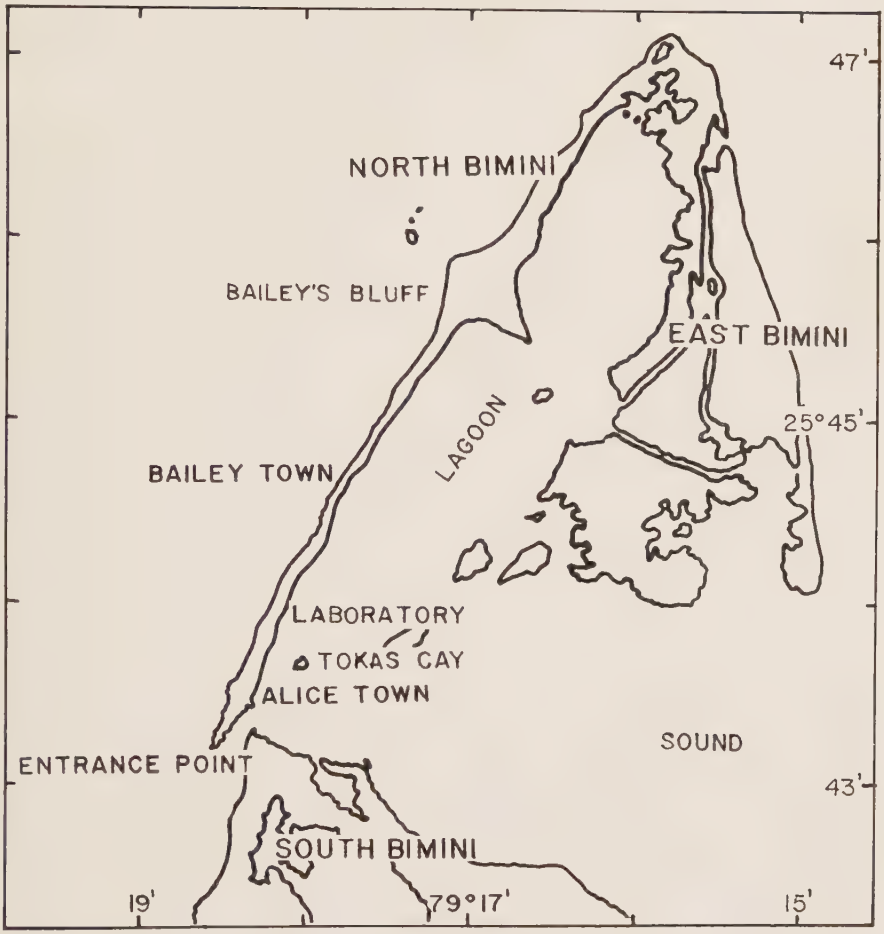

FIGURE 1. Map of Bimini, Bahamas, showing localities discussed in the text.

the exposed surface.

On the western side of North Bimini the shoreline is composed almost entirely of the exposed limestone with areas of sandy beaches. Southward, especially at Entrance Point, the rocks dip slowly below the sea, permitting a considerable extent of wave-eroded rock to be bared at low tide, and the formation of numerous tidepools. Offshore, the bottom falls away rapidly at a distance of several hundred yards, forming the "drop-off" marking the eastern edge of the canyon of the Florida Straits.

To the north, east and south the islands are surrounded by the shallow water of the Great Bahama Bank which terminates miles to the eastward at the Berry Islands. This bank is composed largely of calcium carbonate sediment and is covered by about 8 to 10 feet of water. Marine life is not plentiful on the bank and the bottom is sparsely covered by marine grasses, calcareous green algae, worm and crab mounds and sculptured by wave action. For a review of the bank and its formation see Newell and Imbrie (1955).

Within the triangle formed by North, East and South Bimini is a large body of water containing scattered islands and having a mean depth of about 3 feet, but on certain tides (mean tidal range 2.4 feet) and winds much of the water may drain out of the bay leaving vast extents of turtle grass, *Thalassia testudinum,* exposed. The nature of the sediments, etc. of the area have recently been described by Newell and Imbrie. The outer portion of the area opening onto the bank is known as the Sound, while the inner portion surrounded by North Bimini and its adjacent islands is called the Lagoon. This again is divided into the Outer and Inner Lagoon (Figure 1).

Ecological Survey

During the period of our visit seven areas were studied in some detail. Examination was made by wading, the use of glass bottom buckets and face plates. Collections were made at all areas and detailed field notes were written on the spot. Tidal zonations were determined by the use of a tide staff and measurements related to tidal data given in the Tide Tables for 1953, supplemented by tidal recordings from the tide gauge situated on the end of the pier at the Lerner Marine Laboratory. The areas are discussed in the approximate order that they were investigated in the field.

Entrance Point

Entrance Point is a low, rocky promontory composed of loosely amalgamated limestone which is soft and easily broken when located in the lower intertidal area but which hardens where exposed to the air as in the higher levels. Tidal and wave erosion is extensive but not of the nature common in the Key Largo limestone of the Florida Keys (Voss and Voss, 1955) where the effect is jagged potholes. Here the rocks are smooth but broken by crevices, mammillated areas and small tide pools.

The point, for convenience, may be divided into three areas: 1)

the high rocky cliffs of the mainland of the island extending from the shore end of the promontory northward along the west side of the island, 2) the rocks adjacent to the shoreline forming the base of the point, and 3) the low rocky island separated from the shore rocks by about 30 feet of open water over sandy bottom which is nearly exposed at low tide. The depth and nature of this divide varies according to the prevailing winds and shifts during blows from the proper quarters. The ecology of Entrance Point will be discussed by taking these three areas in the order given and discussing the fauna and flora found and the existing ecological conditions.

Rocky cliffs north of Entrance Point. The rocky cliffs are formed of a high limestone formation deeply eroded by wave action, their bases rising about 5 feet above MLW, precipitous and nearly vertical or even slightly undercut. There are numerous tide pools often located well above the high tide limit. Along this area and in several others visited, the color zones delimited by Stephenson and Stephenson (1950) in the Florida Keys are clearly seen and along the seaward cliffs rise to a height nowhere seen along the low face of the Florida Keys. At Soldier Key, reported upon by the authors, the total rise of the shoreline from MLW to the spray zone is only about 3 feet. In contrast, at the rocks under discussion, the vertical height of the color zones is about 12 feet and only limited shoreward by the beginning of land vegetation. This, of course, is partly due to the high elevation of North Bimini in contrast with that of the Florida Keys, and partly because the shore here is directly exposed to the pounding of the surf from the open sea whereas the shoreline of the Florida Keys is protected by the well developed barrier reef and extensive shallows extending from three to six miles seaward.

The platform face (for terms see Voss and Voss, 1955) is about 5 feet in vertical distance from MLW and above this the upper platform slopes rather quickly upward to the line of vegetation. In the Florida Keys this upper platform is usually nearly flat, rising only very gently if at all.

The yellow zone is approximately 5 feet in height above MLW and completely covers the platform face. The lower part of the zone occupying the area from MLW to HW was composed of a mixed algal mat from ¼ to 1 inch thick formed of *Bostrychia tenella* (?), *Padina sanctae-crucis, Laurencia poitei, Corallina cubensis, Cladophoropsis membranacea* and *Valonia ocellata.* Above the HW mark the yellow zone was mainly found to consist of *Bostrychia tenella* with occasional

clumps of *Valonia ocellata.* Newell and Imbrie (1955) state that the extreme low tide level is marked by a projecting lip of limestone coated with a coralline alga similar in appearance to *Porolithon* in the Pacific. This was termed the pink zone but was not noted by us. Below this lies a narrow lower platform only two or three meters wide.

Above the yellow zone the black zone began abruptly and extends upwards for a vertical height of 2 feet and a horizontal distance of 3 to 6 feet. The black zone blended gradually into the gray zone with a vertical rise of about 1 foot and a horizontal width of about 27 feet. Shoreward of this the white or spray zone extended upwards for about 3½ feet and horizontally for about 30 feet, both its horizontal and vertical range limited by the vegetation line.

The fauna of the intertidal zone was here rather sparse in species. The animal occupying the lowest part of the range was *Echinometra lucunter,* the boring sea-urchin, which ranged from just below LW to about the MT mark. In the Florida Keys this species occupies holes in the rocks below MLW and in the absence of tide pools does not extend upwards. In this area, however, it has taken advantage of conditions, mainly tide pools, to extend its vertical range.

From MT to HW were scattered specimens of the West Indian top shell, *Livona pica,* a common Bahamian species widely sought as food and not met with in the Florida region. Accompanying it were numerous chitons, *Acanthopleura granulata,* which extended to the HW mark and as scattered individuals to the limit of the yellow zone. A noticeable feature of the intertidal rocks was the sparsity of barnacles which, in the Florida Keys, cover the rocks. *Tetraclita squamosa stalactifera* and *Chthamalus stellatus* were the predominant barnacles. *Tetraclita* ranged from LW to MT and *Chthamalus* from MT to above the HW mark.

A prominent feature of these rocks was the presence of many small to large tide pools within the yellow zone. These pools supported a mixed population of animals normally occurring below LW such as the keyhole limpet, *Fissurella* (*Crimedes*) *barbadensis,* and a small reddish brown gastropod, *Littorina mespillium,* which often almost covered the bottom of some pools. The purple shells, *Thais rustica* and *T. patula,* were found at about HW and also in the pools. One common inhabitant of the pools which often occurred in vast numbers was the young of *Echininus nodulosus,* which, however, was by no means confined to this habitat but was also found all over the rocks. *Siphonaria alternata* was found from HW into the pools and upward

into the lower black zone. Three species of *Nerita, N. tessellata, N. peleronta* and *N. versicolor,* in that order according to numbers, were found scattered throughout the yellow zone and *N. versicolor* also into the lower black zone. *Littorina meleagris* was found in the tide pools up to the lower black zone. Throughout the entire area were numerous specimens of two species of grapsoid crabs, Sally-light-foot, *Grapsus grapsus,* and a smaller species, *Pachygrapsus transversus,* both of which retreated into the water when approached. The former was absent from Soldier Key and is not found in the Upper Keys.

One of the commonest animals on the rocks was the gastropod, *Echininus nodulosus,* which ranged from HW to the upper gray zone, a horizontal distance of 33 feet and a vertical distance of 6 feet. The lower animals were mostly small while large specimens were found at the upper limit. Its ever present companion, *Littorina ziczac,* had a slightly greater range, extending from HW to the middle of the white zone, a distance of 48 feet. *Tectarius muricatus* was found from the gray zone upwards to the low hardy bordering bushes, and it was often found in the lower branches of the shrubs.

Shore section of Entrance Point. The upper platform is about 30 feet wide and lies mostly above the high tide level in the black and gray zone. It is flatter than in the area just described and ends at the seaward side in a low precipitous ledge whose upper limit is the HW and the lower limit the LW. The color zones on this ledge are distinct. The yellow zone occupies the entire tidal range, superseded above by a narrow black zone above HW which gradually blends into the gray zone. Further up the beach in the area described above, the surf is much stronger and the yellow zone as a consequence reaches a greater vertical range.

Fissurella barbadensis was found to occur from LW to HW living on the open rock face in the lower part but dwelling in crevices near HW. Accompanying it and concentrated in a 4 to 5 inch band at MT was the barnacle, *Tetraclita.*

On the platform face, occupying a narrow band about 3 inches wide, were large numbers of the boring barnacle, *Lithotrya dorsalis,* with as many as 10 specimens in an area 5 inches square. Scattered specimens occurred from LW to about 1 foot below HW, accompanied by the boring sponge *Cliona,* and numerous sipunculids belonging to about 3 different genera and species. Here also was found another boring animal, the date shell, *Lithophaga antillensis. Acanthopleura granulata,* the chiton, were numerous from MT to above HW and

in tide pools some distance back. Occupying about this same range were *Siphonaria alternata, Echininus nodulosus, Littorina ziczac, Chthamalus stellatus, Tectarius muricatus* and *Littorina mespillum* in tide pools. In crevices in the intertidal and in tide pools was the small bivalve *Isognomon alata.*

A few counts were made of some of the common animals which were very crowded in certain areas. In an area of one square foot were found 32 *Nerita versicolor,* 2 *N. peleronta,* 1 *N. tessellata,* 11 *Littorina ziczac,* 17 *Echininus nodulosus* and 4 *Chthamalus stellatus.* In another more concentrated area of 4 sq. inches were 31 *L. ziczac,* 15 *E. nodulosus* and 2 *Chthamalus.*

The most conspicuous inhabitants of the entire area were the three *Nerita.* Specimens covered the rocks in extensive patches from LW to the end of the upper platform, but different zonations occurred between the species. For instance, *N. tessellata* was more numerous from LW to MT, *N. peleronta* from MT to HW and *N. versicolor,* the most numerous of the three, was found from LW to the end of the platform. *Thais rustica* was scattered from MT to HW and *Leucozonia ocellata* and *Purpura patula* were found from HW to the upper platform.

A dominant organism in the intertidal area was a small alga, *Heterosiphonia secunda,* which formed small mats about ¼ inch in diameter. These appeared black when dry and they spotted the entire area. Numerous hermit crabs occupied the shells of *Murex, Cerithium* and *Modulus* and in the tide pools snapping shrimp, *Synalpheus,* were numerous.

The rocky islet separated from the point by a few yards of current scoured sand contained few animals and plants and was not considered worth detailed study. According to local observers these rocks are often buried under the sand for long periods.

Rock ledge by airplane ramp. Just below the airplane ramp on the east side of the island and nearly opposite the rocky shore reported on above, was an aggregated rock ledge or cliff, slightly undercut at its base. In its zonation it offered striking contrast with the outer rocks since the harbor is not subject to much wave action and the color zones as a result were contracted, very marked and clearly demarcated. The cliff was about 5 feet high, undercut about 3 feet and deeply eroded in its lower limits. The yellow zone was about 2 feet broad, the black zone about 8 inches, and above this the rest of the cliff was gray. On the southern part of the cliff the yellow zone was composed

nearly entirely of *Cladophora* and *Enteromorpha*. The animals present on the outer rocks were again encountered here in the same zones but in much lesser numbers with the exception of the barnacle *Tetraclita* which formed a distinct belt at the MT area.

Shore from Laboratory Point to Bailey Town

From just within Entrance Point to the Laboratory dock north of Alice Town, the shore is in general sandy, shelving out rather quickly to the "Channel" which is only about 8 to 10 feet deep. The flats on either side and the channel bottom are thickly covered with turtle grass, *Thalassia testudinum*, and other marine "grasses" of which the next most common is *Cymodocea manatorum*. Directly along the shore outward to a distance of about 50 to several hundred feet the bottom is clear with only occasional patches of grass. Scattered about on the sand are shell heaps (broken shells of the pink conch *Strombus gigas*) and some rock and mangrove logs. To these hard objects various algae are attached and about these and the pilings of the docks are clustered large numbers of the black urchin, *Diadema antillarum*. This urchin is most common near Entrance Point but disappears near the laboratory dock, preferring clear ocean water.

Northward of the laboratory dock the shore is mud and sand, lined with mangroves and below MLW the bottom is covered with marine "grasses" and clear sand areas. In general the grass was *Thalassia*, but often intermixed with *Diplanthera wrightii*. In the clear patches of sand two species of *Halimeda, H. incrassata* and *H. scabra* were found, the former very commonly. The main attachments for algae were half-buried shells and attached to these throughout the flats were small plants of *Padina Sanctae-Crucis, Batophora oerstedi, Laurencia poitei* and patches of *Cladophoropsis*. An unidentified species of *Dictyota* also occurred, as well as *Acanthophora spicifera*. Growing directly in the sand were numerous tufts of *Penicillus pyriformis*. Lying loosely in the grass were small clumps of a coralline alga, *Lithothamnion* sp. and the green alga, *Acetabularia*, was common attached to hard objects. An interesting feature of the intertidal shore at low tide was a zone in the upper level formed of "green hair" *Cladophora glaucescens*. This belt was found along the shore throughout much of the Lagoon.

The shallow water fauna was neither numerous nor extensive. Perhaps commonest were the long gelatinous egg strings of a polychaete worm. They were often accompanied by the sand collar egg

cases of *Polinices.* Within a mass of *Halimeda* was a single anemone, *Condylactis gigantea.* Brachyuran crabs were represented by numerous small specimens of *Callinectes exasperatus* and a single *Panopeus occidentalis.* Mollusks were represented by scattered *Strombus gigas,* and a single washed out but living *Asaphis deflorata* and a *Pecten antillarum* was taken from the base of the Paul Jones dock. Dead specimens of *Codakia orbicularis, Strombus raninus* and *Fasciolaria tulipa* were present while thousands of the small snail *Cerithium litteratum* were found in the grass beds. Echinoderms were represented by scattered small cushion stars, *Oreaster reticulatus,* and the shallow water and sediment-tolerant rose coral, *Manicina areolata,* was not infrequent.

The pilings at both the laboratory dock and the adjacent Paul Jones Dock were examined closely and revealed a considerable number of inhabitants. The marine plants consisted of a growth of *Dictyota indica* from the sand level to about midtide, superseded by a dense low growth of *Bostrychia tenella* up to the high tide level.

The piling crab *Pachygrapsus transversus* was always present, the females gravid, and three specimens of Sally-light-foot crab, *Grapsus grapsus,* were seen. The sea roach, *Ligia,* was numerous. The shells of *Batillaria minima,* occupied by small pagurids, were plentiful on the pilings and the false limpet, *Siphonaria alternata,* occurred from MT to above HW. The ribbed barnacle, *Tetraclita,* was found clustered at MT. *Chthamalus stellatus* and another unidentified balanoid also were present. *Littorina angulifera* was numerous in the upper tidal levels and above along with occasional *Tectarius muricatus.* The bivalve *Pedalion alata* with *Spirorbis* sp. on its shell was found from MT to LW and below. Wood borers were numerous but not identified to species. *Limnoria* sp. and several sipunculid worms were occupying the calcareous tubes or borings of *Teredo.* A tunicate, possibly *Clavelina,* was found below low water and a single colony of a red tunicate, *Botryllus,* was found in the same zone. Hydroids were numerous.

On the mangrove roots and pneumatophores north of the laboratory were found *Nerita fulgurans,* and *N. versicolor,* while *N. tesellata* was found on an empty conch shell. *Littorina angulifera* was plentiful and all of the pneumatophores and roots were covered with dense masses of *Bostrychia.*

Near the end of the laboratory pier a large number of empty conch shells had been dumped to form a refuge for various animals. Exami-

nation during the daylight hours revealed numerous sea-urchins, *Diadema antillarum, Tripneustes esculentus* and *Eucidaris tribuloides.* Two corals were also present, *Manicina areolata* and *Porites porites,* although some of these may have originated from the dumpings of the aquaria. At night, however, under the glare of the light, great numbers of the bristle worms, *Hermodice carunculata* and *Amphinome jamaicensis,* were seen crawling about over the shells, which were occupied at the time of the study by two octopuses, *Octopus vulgaris.* The red bristle worm, *Chloeia viridis,* was less numerous. A single specimen of the holothurian *Actinopyga agassizi* was seen and a small sponge crab, *Dromidia antillensis,* was also observed.

One night, two tectibranchs were captured, one a bright orange red, the other striped gray and black. When placed in the aquarium the smaller striped one disappeared before morning and it was presumed that it was eaten by the other. A later second specimen was relaxed and preserved along with the orange red species but identifications are unavailable at present.

Tokas Cay

Tokas Cay is a small island of perhaps an acre in area overgrown by mangroves and situated in the middle of a shallow flat opposite Government Dock at Alice Town. It is separated from North Bimini by an extent of comparatively deep water (8 to 10 feet). The flats are covered by extensive beds of turtle grass intermixed with manatee grass, *Cymodocea manatorum.* Clear areas of deposited calcareous muddy sand are scattered over with *Penicillus.* Loggerhead sponges, *Spheciospongia vesparia,* are not uncommon and occasional clumps of *Porites* are found. The flats around Tokas Cay are covered at HW by about 2 feet of water which becomes shallower in the vicinity of the island. The immediate border of the island is composed of a strip about 20 feet wide of clear white sand occupied by scattered specimens of *Penicillus.*

The mangroves surrounding the cay extend out into the water sending up thousands of pneumatophores. The mangroves were the host of many *Littorina angulifera* above HW. Below LW were numerous hydroids, scattered bivalves, *Pinctada radiata,* and a few *Diadema antillarum* among the roots. A single edible urchin, *Tripneustes esculentus,* was also seen here.

Around the east side of the island the narrow sand strip was filled with broken conch shells, extending around to the south side. These

shells offered a substrate for large numbers of the blue tipped sea anemone, *Condylactis gigantea,* and a few *Aiptasia annulata* each usually accompanied by its commensal shrimp, the keyhole limpets *Diodora listeri* and *Lucapina sowerbii* and two algae, in shallow water *Bostrychia tenella,* and in deeper water (3 feet) mats of *Batophora oerstedi.* Numerous fish also sought refuge within these shells (Breder, 1950) which have been overlooked in many areas as forming a quite distinct, ecological niche in areas deficient in hard bottom. The sponge *Ircinia strobilina* was very common along with the red fire sponge, *Tedania ignis.* A feather worm, *Sabella melanostigma,* with a crown of purplish gray tentacles formed numerous tubes on the buried rocks and shell and is a favorite in the aquaria at the laboratory. Another worm, *Polymnia nebulosa,* was also taken. The holothurian *Actinopyga agassizi,* usually accompanied by the commensal fish *Carapus bermudiensis,* was found lying about on the dead shells and a few *Nerita versicolor* were found on the rocks.

The sandy area of the west and north side were rather barren with no broken conch shells. A single live *Laevicardium laevigatum* was taken at the west end and a few specimens of the crab *Callinectes exasperatus* were also noted. In this area especially on the north side were small low clumps of *Halimeda opuntia* which sheltered numerous worms, and a specimen of *Caulerpa* sp. In some *Dictyota* a single *Microphrys bicornutus,* a common crab of the West Indies, was obtained and in a clear area a specimen of the snail *Polinices lacteus* was found, the species being noted for its wine red operculum.

A common alga on the mangrove roots was *Catanella opuntia* which was also reported by Humm. A few algae from Tokas Cay were collected: *Penicillus capitatus, Dictyota indica,* and *Dictyota* sp., *Udotea flabellum,* a species of *Caulerpa, Laurencia poitei,* and *Halimeda opuntia.*

A number of mollusks were found, the most numerous being the little *Batillaria minima.* A few *Nerita versicolor* were found in the mangrove roots and the keyhole limpet *Lucapina sowerbii* was taken from below LW. The starshell *Astraea longispina* was uncommon except on the grass. *Isognomon alata* was attached to grass stems and two cerithiums, *Cerithium litteratum* and *C. muscarum,* were common. A single ark shell, *Barbatia tenera* or *candida,* and the irregularly coiled shells of *Vermicularis spirata* were everywhere.

Bailey Bluff

A single trip was made to Bailey Bluff for examination of the

limestone cliffs in that area where they have a different formation from that in the southern part of the island. This is the highest land on North Bimini and forms a high sand bluff with a steep seaward side terminating in a high aeolian limestone cliff. The descent down the cliff is facilitated by the layering of the rock into thin layers about 1-2 inches in thickness from which sections have been broken forming a staircase type of surface. At low tide in much of the area the base of the cliffs descends into a sand beach of a few dozen feet in width. This beach and the cliffs are subject to heavy scouring from wave action and little life, other than ubiquitous blue-green algae which coat the rocks, was seen. Separated from the shore by about 20 feet of water was a chimney-like rock rising abruptly from the water for 8-10 feet. Its sides were inhabited by numbers of large chitons, *Acanthopleura granulata,* but at the time of year of our visit, at least, no other animals were observed and no macroscopic algae coated the rocks. Even the color zones were mostly absent.

Flats in the Lagoon

Proceeding southward from the Lyons estate and Bailey Bluffs an afternoon was spent on the shallow flats of the Lagoon. This is a broad area of shallow flats seldom more than two feet deep. It is pierced along its west side by a narrow small boat channel dredged into the Lyons estate. The water in the Lagoon has little movement of consequence, there being little tidal current, and it is probable that there is little or no water exchange with the southern part of the Lagoon. As a result the area may be classed as stagnant and this is shown also by the paucity of grass beds on the banks and certain stagnant water forms such as the jellyfish, *Cassiopeia xamachana.*

The marine plants on the banks were mostly sparse stands of the turtle grass, *Thalassia testudinum, Penicillus capitatus,* and *P. pyriformes* in the clear areas with low patches of *Batophora oerstedi* growing attached to rocks and shells, and scattered *Halimeda tridens* and the red alga *Laurencia poitei.*

One of the interesting animals found on the sparse grass in the sandy area was a species of colonial tunicate strongly marked with orange and red, possibly a species of *Botrylloides.* A less common species, if distinct, was emerald green. Both encrusted the leaves of the turtle grass over much of the area.

There were only a few mollusks. The pink conch, *Strombus gigas,* is seldom found in the Bimini area probably due to over-fishing by

the native population who use it as a staple food. A few specimens of *Strombus raninus,* the tulip shell *Fasciolaria tulipa,* the moon shell, *Polinices duplicata,* and occasional specimens of the pen shell and *Pinctada radiata* which grows attached to the grass by its byssus, were found by diligent searching.

Northwest shore of South Bimini

The north shore of South Bimini forms the east side of the entrance to the Lagoon and the harbor at Alice Town. It is protected by Entrance Point which overlaps it and is separated from it only by the rather narrow channel. The shore is sandy, gently sloping on the northern part and more steeply sloping to the westward. Since a rather strong tidal current sweeps past this beach close inshore, there is little plant or animal growth although a number of oceanic plants, *Sargassum* spp., and the shells of offshore mollusks are constantly being cast up above the tide marks, during the periods of flood tides. Little attention was paid to the area due to its tide swept nature and no characteristic animals or plants can be listed. The remains of an old pier are located on the north side of the point and this is a favorite location for night lighting and dipnetting for oceanic planktonic animals which are swept into the Lagoon on the strong parts of the flood tide. Night collecting is also enhanced in interest here by the very evident reluctance of the native boatmen to venture off or even near the shore end of the pier during the night hours due to the reported presence of the islands' evil spirits, the chickcharneys. Supposed nests of these evil creatures were pointed out by the natives, being located by the crossing of the tops of three or more pine trees. The chickcharneys are here mentioned only to make more complete the list of native animals, earthly or otherwise.

Salt Creek, South Bimini

Salt Creek is a deep indentation in the north end of South Bimini, partially separated from the Lagoon by several small islets. It is very shallow, only a few inches of water over the bottom at normal low tide and probably largely bare on a low spring tide. The bottom is mostly open silty mud, with patches of sparse grass and the whole is slowly being changed into land by the growth of mangroves. Even the open areas are spotted with freshly rooted mangroves and seedlings rising above the water. Near land these mangroves are larger and more developed. Few animals were reported from this area, those in our

records including the worm *Haplosyllis spongicola,* and the bivalve mollusk, *Laevicardium laevigatum.* The area is subjected to high salinities and high temperatures during the summers and this in part is probably the cause of the dearth of organisms here, coupled with lack of active collecting, especially in more cryptic forms.

Discussion

The marine fauna of the Bimini Islands is very poorly known and hence generalizations drawn on the area may be subject to error in the light of further study. However, despite these deficiencies certain features seem worthy of mention and some conclusions may be drawn.

In general, the marine invertebrate life is sparse, in contrast with many other tropical areas. In comparison with the ocean side of the Florida Keys and its shallow waters, it appears impoverished. This is also true of comparisons drawn between the Biminis and the eastern islands of the Bahamas. Although enough legitimate records are not available, there seems to be a sharp and steady decline in the species present as one passes from east to west over the banks. This is probably due to hydrographic conditions.

C. L. Smith (1940) studied the hydrography of the bank areas, especially in the vicinity of Andros Island. His studies show that the bank water stays for long periods of time in the shallows, moving somewhat erratically under the influence of the prevailing winds. As a result of this sojourn on the banks, the salinities may increase to as much as 43‰ and considerable variation in temperature is found, with an average maximum in summer of 29.7°C (individual maximum of 30.5°C and a minimal value of 21.6° in winter with an individual minimum of 19.5°C, all data based upon 1939 observations). He states "The semi-static state of the water which is a byproduct of the opposing tidal influences discussed above and the sheltering effect of the land masses to the east, favors the development and maintenance of hydrographic properties very different from those shown by the surface waters of the open ocean." This type of water I have chosen to call "stale" water, for the purpose of discussing faunal distribution.

While, as Smith states, the water moves erratically under the influence of opposing and changing winds, in general the movement is across the bank from east to west under the influence of the prevailing winds. This means, as far as Bimini is concerned, that the waters found surrounding the island, in the Lagoon and Sound and to the eastward, are, in general, of quite a different nature from the waters flowing by

in the Florida Current to the westward. This is revealed by the nature and composition of the marine fauna and flora. It is also substantiated by the marked differences between Bimini and Soldier Key, Florida.

There is little coral growth in the western Bahamas, and what coral is found is not luxuriant. Except for *Porites* and *Manicina,* few corals are found in the shallows and these not in quantity. The big stands of *Acropora* and other massive reef corals so common along the outer side of the Florida Keys are missing and what is found is confined to somewhat deeper water. On the contrary, in the eastern Bahamas, reef corals grow luxuriantly and magnificent reefs occur at Abaco, Exeuma, Eleuthera and Andros. Several features are probably at play in Bimini, among the most important probably being a deficiency in oxygen, insufficient plankton for food and rather high sedimentation.

Changes in oxygen content, etc., have not been observed in stations occupied by The Marine Laboratory, University of Miami, along the eastern side of the Florida Current. Possibly this is because the stale water flowing off the bank on the ebb tide or during easterly winds is picked up and swept northward by the Florida Current and little mixing in the area of origin occurs.

Another explanation for the dearth of corals and marine invertebrates in general may be that the waters of the banks are not suitable to support the life of the larvae. Larvae of all kinds are particularly susceptible to small changes in water conditions. If this is the factor at play, it would easily explain the lower number of species at Bimini and Cat Cay in contrast with the eastern islands and the Florida Keys. Further support for this may be seen in studies carried out by The Marine Laboratory along the eastern side of Andros where hydrographic studies in the Tongue of the Ocean show a continual change in conditions from Nassau southward to the end of the Tongue. Studies of the invertebrate fauna along the Andros reef confirm the fact that this fauna decreases by species and numbers as one progresses southward and the water becomes "stale."

The survey of the Sound indicated that clear ocean water is found in Bimini Harbor only for a comparatively short distance along the north end of South Bimini and the east shore of North Bimini to about the north end of Alice Town. The Lagoon in particular has little circulation and is definitely stagnant. This is upheld by the large numbers of the jellyfish *Cassiopea* found in the area. This jellyfish in the Florida Keys is usually confined to semistagnant areas and is found in numbers only in confined areas such as dredged out basins, deep pools sur-

rounded by extensive flats, the moat at Dry Tortugas, etc. While the cut at Entrance Point should permit equal periods of ebb and flow, this apparently does not occur and there is a greater outflowing of stale water than is compensated for by clear Straits' water.

Despite these conditions, several important species occur in the Biminis that are absent from the Florida Keys. Among these may be mentioned *Livona pica, Fissurella barbadensis, Grapsus grapsus, Littorina mespillum* and a number of algae. The occurrence of *Livona* alive on the Florida coast is debatable and has never been proved. Only two or three instances of living specimens in the Florida Keys have been reported. These may all be explained by their having been brought over by fishermen from the Bahamas and Cuba as part of their food supply. That they formerly lived in South Florida can be shown by fossils in the limestone in the Florida Keys, and there probably was an exchange during pre-Columbian times as they are sometimes found in kitchen middens. However, over most of the Keys coastline, proper habitats are lacking. *Fissurella barbadensis* is very well marked and is unknown from Florida but common in the Bahamas and Caribbean. *Grapsus* likewise is missing from Florida and *Littorina mespillum* is rare or wanting.

A careful study of these differences seems to indicate that while the Bahamas and south Florida lie directly opposite each other and both are tropical, that the Florida Keys have been populated largely by fortuitous invasion and by a route around the west end of Cuba by way of the Yucatan Channel. This route appears to have limited the Florida Caribbean fauna in respect to certain of its shore species while the Bahamas have been populated around the east end of Cuba and directly from the north Cuban coast, and by easy stepping stones of the southern Bahamas.

On the other hand, south Florida has many species, derived from the temperate fauna, that have not entered the Bahamian fauna. These temperate species are well able to dwell in tropical waters, being eurythermal. Their presence in south Florida does not indicate a subtropical habitat, since it is the lower temperature limits which control, in the main, the distribution of marine animals and not the upper. Thus the 20°C isotherm is the northern limit of the tropical zone, but it is not the southern limit of the boreal or temperate in eurythermal forms.

That much of the temperate fauna is lacking in Bimini and the Bahamas in general may be due to two factors. Of course, there is

no landbridge connection between the temperate continental coast and the Bahamas to allow them to enter. However, the distance between the Florida coast and the western Bahamas is not great and invasion could easily have taken place, except for the barrier of the swiftly moving northbound Florida Current. The student of insular populations would not give too much credence to such a barrier as over a sufficient number of years such a migration most certainly would have taken place. What seems more evident is that the different nature of the water mass on the Bahama Banks would not support the planktonic larvae after a crossing was made. The two factors probably work together.

A comparison of the two shorelines, Soldier Key and North Bimini, show mostly the differences caused by the more exposed position of North Bimini. Soldier Key is protected by a shallow bank and the mainland on its westward side. To the eastward, or seaward side, it is protected by a moderately shallow bank, about 4 miles wide, from the beating of the seas of the Straits. Bimini, on the other hand, is protected to the eastward by the Great Bahama Banks but unprotected to the westward, or seaward, side. The western shelf is rather deep and narrow. As a result, the height covered by wave action is greatly increased with a resultant broadening of the intertidal zone. Even so, Bimini does not receive heavy surf action under normal conditions, except in full northwesters, since the prevailing winds are from the easterly quadrant. All of these factors strongly affect the intertidal fauna.

While the bank water surrounding the Biminis may be inimical to open ocean larvae, it supports a varied and rather rich life of its own, plankton tows revealing for instance a copepod fauna quite distinct from that of the Straits or of the ocean to the eastward. This is not well enough known as yet, however, to warrant any conclusions.

It is perhaps surprising that there is not a much richer infauna represented in the area, especially on the banks, since there seems to be a rather high amount of organic detritus in the mud and sand. Recent work by Jeanne Renaud-Debyser (1955) on the interstitial sand fauna of the Biminis has revealed that the interstitial fauna of this calcium carbonate type sand is considerably richer than silicate sands, adding considerably to their productiveness.

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NOTES ON BERMUDA HERMIT CRABS[1] (CRUSTACEA; ANOMURA)

ANTHONY J. PROVENZANO, JR.
The Marine Laboratory, University of Miami

Abstract

Seven spp. of pagurids from Bermuda shallow waters are listed and discussed. The status of *Calcinus verrilli* (*Clibanarius verrilli* Rathbun) as endemic to Bermuda is confirmed. *Clibanarius hebes* Verrill (in part) and *C. brachyops* Bouvier are probably referrable to *C. tricolor* (Gibbes). *Clibanarius antillensis* Stimpson and *Pagurus miamensis* Provenzano are new to Bermuda. Availability of gastropod shells is probably a limiting factor in abundance of hermit crabs in this locality. The three most abundant species occupy different ecological niches.

Introduction

A recent treatment of many of the West Indian littoral pagurids (Provenzano, 1959) left a number of problems in this group untouched. Since Verrill's general discussion of the decapods of Bermuda half a century ago nothing has been written concerning the pagurid fauna of those islands and the two species listed as endemic at that time have been unreported. Examination of co-types of *Clibanarius verrilli* Rathbun revealed that the generic status of that species was questionable. Search through collections failed to turn up the illustrated type of *Clibanarius hebes* Verrill, but examination of the paratypes indicated that more than one species was before Verrill at the time of his description of *C. hebes*. The age and small number of specimens did not facilitate solution of these problems, and with the aim of obtaining additional material the writer visited 27 localities at Bermuda in November 1958.

I am most grateful to Dr. William H. Sutcliffe, Jr., Director of the Bermuda Biological Station, for his kindness before, during, and after my stay there, and to other members of the staff for their assistance. Dr. Willard D. Hartman of the Yale Peabody Museum and Dr. Fenner A. Chace, Jr. of the Smithsonian Institution were helpful in providing material from their collections for study. I am sincerely grateful to Dr. Jacques Forest of the Paris National Museum of Natural History for examining specimens sent him, and for permission to quote portions of his correspondence.

Contribution No. 261 from The Marine Laboratory, University of Miami.
[1]Contribution No. 266 from the Bermuda Biological Station; assisted by a National Science Foundation Grant-in-Aid through the Biological Station.

All material from shore localities was collected by wading or shallow diving, but the off-shore collections were made with the aid of a boat and aqua-lung to depths not exceeding 25 feet. The material collected was divided among the following institutions: Yale Peabody Museum of Natural History; Smithsonian Institution; Paris National Museum; and the University of Miami Marine Laboratory.

TABLE 1

LIST OF LOCALITIES VISITED AT BERMUDA AND SPECIES COLLECTED AT EACH, 5-14 NOVEMBER 1958.

Locality	*Species Found*	*Number*
Coney Is. Bay	*C. tricolor*	many
	P. miamensis	8
Coney Is., east side	None	
Bailey's Bay	*C. tricolor*	1
Pt. at Shelly Bay	*C. verrilli*	2
Rocky tide pools west of Shelly Bay	*C. tricolor*	2
	P. miamensis	1
Gibbet Is.	None	
Harrington Sound at Flatts Bridge	*P. miamensis*	1
Ducking Stool	*C. verrilli*	1
Mangrove Bay	*C. tricolor*	many
	C. antillensis	1
Ely's Harbor	*C. tricolor*	many
Somerset Bridge	*C. tricolor*	a few
Coral heads off Wreck Hill	*C. verrilli*	many
	P. miamensis	a few
Hungry Bay	*C. tricolor*	many
	C. tibicen	1
Devonshire Bay	*C. tricolor*	a few
Smith Beach	*C. verrilli*	a few
	P. miamensis	a few
Pink Beach	*C. verrilli*	a few
	P. miamensis	a few
	C. tricolor	many
Boilers, S.E. shore	*P. miamensis*	3
Charles Is., outside slope	*C. verrilli*	15
	P. miamensis	17
	C. tibicen	7
Tuckerstown Pt.	None	
Dolly's Bay	*C. tricolor*	a few
St. Georges Harbor	*C. tricolor*	many
Tobacco Bay	None	
Ferry Reach (Biol. Station)	None	
Western Ledge reef	*C. verrilli*	2
Coral heads in western lagoon	None	
Three Hill Shoal	*C. verrilli*	6
North Rocks Reef	*C. verrilli*	23
	P. miamensis	6

Coenobita clypeatus (Herbst, 1791)

Cancer clypeatus Herbst, 1791: 22, figs. 2a, 2b.
Cenobita diogenes, Verrill, 1908: 438, fig. 55.
Coenobita clypeatus, Provenzano, 1959: 359, figs. 3a, 3b, 3c.

Verrill remarked on the use of fossil shells by this species and on its occurrence far from shore. Although no specimens of this land hermit were taken during the brief collecting period available for this study, it is still present, for members of the Biological Station reported having seen specimens recently.

Pagurus miamensis Provenzano, 1959

Pagarus miamensis Provenzano, 1959: 414, fig. 21.

This was one of the three most abundant pagurids taken. That it hasn't been noticed before may be due to its avoidance of the inter-tidal zone, for it is usually found at depths of one fathom or more. Its range is now extended from Florida and the Bahamas. A number of the females taken were ovigerous.

Dardanus venosus (H. Milne-Ed., 1848)

Pagurus venosus H. Milne-Edwards, 1848: 61.
Dardanus venosus, Verrill, 1908: 441, figs. 58, 59.
Dardanus venosus, Provenzano, 1959: 374, fig. 6.

This is probably the largest hermit occurring at Bermuda and the general scarcity of suitable shells may be one factor responsible for the absence of greater numbers of individuals. Only one specimen was seen, and that at the government aquarium, in one of the fish tanks. It had been collected "on the reefs."

Clibanarius antillensis Stimpson, 1862

Clibanarius antillensis Stimpson, 1862: 85.
Clibanarius antillensis, Provenzano, 1959: 368, fig. 5b.

A single specimen, establishing the first record of this species at Bermuda, was taken on rocky sand at the beach on Mangrove Bay, near the intersection of Mangrove and Somerset Roads, only a few yards away from large colonies of *C. tricolor.*

Clibanarius tricolor (Gibbes, 1850)

Pagurus tricolor Gibbes, 1850: 189.
Clibanarius tricolor, Verrill, 1908: 447, figs. 61, 62, 63.
Clibanarius tricolor, Provenzano, 1959: 366, fig. 5a.

Without question this is the most abundant hermit crab along the Bermuda shores, for intertidally it is found wherever small shells are available, congregating at low tide in colonies by the hundreds. It seems to be especially fond of protected rocky or shelly shores, but may

also be found at depths of a fathom or more, as at Pink Beach where a large series was taken from depressions beneath rocks, on hard but somewhat sandy bottom. Some of the females were ovigerous.

Verrill stated that it is easily distinguished from all others by its remarkable blue coloration, but he was unaware of the color in life of *C. verrilli* (q. v.)

Calcinus tibicen (Herbst, 1791)

Cancer tibicen Herbst, 1791: 25, pl. 23, fig. 7.
Calcinus sulcatus, Verrill, 1908: 439, figs. 56, 57, & pl. 28, fig. 7.
Calcinus tibicen, Provenzano, 1959: 363, fig. 4.

Occasionally taken intertidally with *C. tricolor,* this species is also found in exposed localities, but it was far from common. Females of this species too, were ovigerous.

Calcinus verrilli (Rathbun, 1901)
Fig. 1

Clibanarius verrilli Rathbun, 1901: 328.
Clibanarius verrilli, Verrill, 1908: 449, pl. 27, fig. 5 & pl. 28, fig. 6.

From examination of the co-type material, it was apparent that this species had been misplaced in the genus *Clibanarius,* for it has all the characters of the genus *Calcinus.* Thus it is now the second species of *Calcinus* known from the western North Atlantic.

The detailed physical description given by Rathbun and repeated in quotation by Verrill mentioned red spots on alcoholic specimens, but the color in life was not recorded. Like other members of its genus, *C. verrilli* is strikingly pigmented in life. Overall color of the hard parts is blue-purple spotted with red. The antennules are vivid blue. The segments of the antennae, although transparent, are edged with faint blue color. The eyestalks are purple near the base but with increasing amounts of red distally. The area immediately proximal to the cornea is white, while the cornea itself is black or black spotted with white. The chelipeds are purple with red patches on the upper, forward margins of the carpus and merus. An irregular row of red pigment along the upper margin of the hand extends onto the movable dactyl. Similar rows of red pigment are present on the upper surface of each ambulatory leg, but do not show in the present side-view illustration.

The species is very abundant on rocks and reefs, but not intertidally. Verrill said his specimens attained 40 mm and that the species becomes much larger. The largest specimens collected during the present study were about 8 mm in carapace length, and the greatest total length,

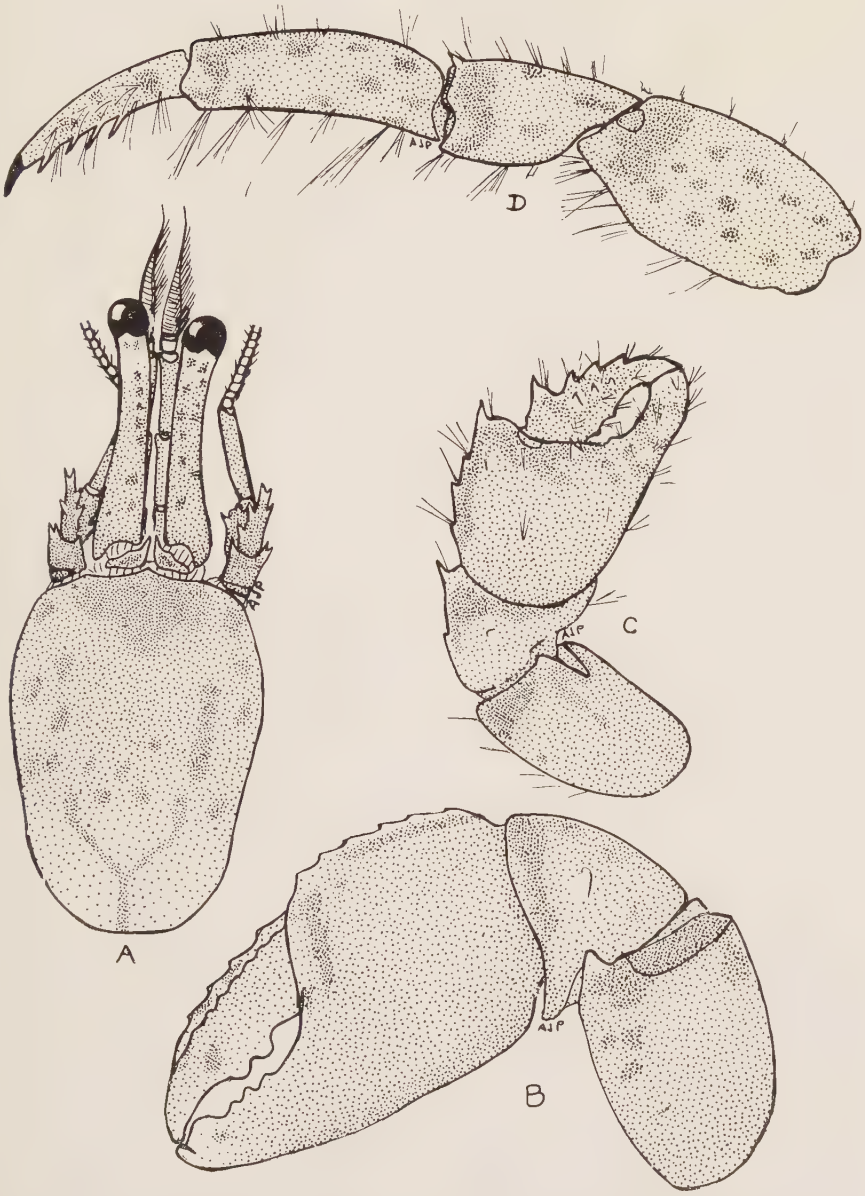

FIGURE 1. *Calcinus verrilli* (Rathbun), a male with total carapace length of 7 mm. A. Anterior carapace and cephalic appendages; B. Major cheliped, lateral view; C. Minor cheliped, lateral view; D. Second left ambulatory leg (p3), lateral view.

even when measured from the tips of the chelipeds (instead of from the rostrum) to the telson, did not exceed 25 mm. None of the females were ovigerous.

Although *C. verrilli* is very distinct from *C. tibicen* of the West Indies, I did not know its affinities to *C. ornatus* of the eastern Atlantic and therefore sent specimens to Dr. J. Forest at Paris who very kindly examined them and who has allowed me to quote him as follows:

> J'ai procédé à une comparaison sommaire de *C. verrilli* à *C. ornatus* (Roux) et je puis vous dire qu'il s'agit sans aucun doute de deux espèces distinctes: la main du chélipède gauche est plus allongée chez le ♂ de *C. ornatus*, et dans cette espèce, les pattes ambulatoires p2 et p3*sont plus grêles, avec un dactyle plus long par rapport au propode. La disposition des marques colorées est tout à fait différente: en particulier les p2 et p3 presentent des lignes longitudinales rouges jusqu' au bord antérieur du propode que est marqué par un anneau d'un brun violacé intense. Le dactyle porte des taches rouges plus nombreuses que chez *C. verrilli*.
>
> Cependant il s'agit de deux espèces apparentées et *C. verrilli* me parait plus proche de *C. ornatus* que des autres espèces américaines.

Verrill was correct apparently, in his belief that *C. verrilli* is endemic to Bermuda.

The Status of *Clibanarius hebes* Verrill and *C. brachyops* Bouvier

Verrill based *C. hebes* on three specimens, the largest being illustrated with photographs and serving as the principal object of his description. Since his material was alcoholic and several years old, there were no distinguishing color patterns to aid him. The largest specimen, of the *cubensis-vittatus* group with acuminate eye-scales, is apparently lost, for a search through the Yale collections failed to turn it up and it seems not to have been deposited in the U. S. National Museum. However, the other two specimens upon which the species was based were found and examined. These do not belong to the same species as the illustrated type, but possess the denticulate eye-scales of the *tricolor-antillensis* group.

The ophthalmic proportions of pagurid crabs have long been used as an important descriptive feature. However, the character is reliable only in fully adult specimens because the ratio of eyestalk length to width changes radically with growth. A large series of *C. tricolor* from glaucothoe to fully adult animals was taken at Pink Beach and from this series some tentative conclusions may be drawn. The identity of

*The symbols "p2" and "p3" as used by Forest and others (referring to pairs of pereiopods) are equivalent to "first" and "second" *ambulatory* legs respectively, as used in this and my preceding paper.

Verrill's lost type of *C. hebes* remains obscure, for despite re-collection at the type locality (Coney Is.), no specimens which might agree with the missing type were found. The smaller specimens of *"C. hebes"* however, except for the absence, due to preservation, of the very diagnostic color patterns, resemble most closely the younger stages of *C. tricolor* taken in the Pink Beach series.

A related problem involves a species described from Cuba. *Clibanarius brachyops* Bouvier, 1918 was erected primarily because the type (presumed by the presence of eggs on the pleopods to be fully mature) had eye-stalks much shorter and stouter than previously described species. It is now known however that female individuals may become ovigerous before attaining the size and the ophthalmic proportions of full-sized adults. As in the case of *C. hebes,* color patterns, so useful in separating some members of this genus, were absent in the type material. It would seem then that *C. brachyops* and *C. hebes* (in part) are referrable to *C. tricolor.* Because of the overwhelming abundance of *C. tricolor* at Bermuda, the evidence is especially strong in favor of this conclusion with respect to *C. hebes* (in part). Nevertheless, because of the very close morphological similarity of *C. antillensis* and *C. tricolor,* the possibility that young specimens of the former species are involved in at least the *brachyops* problem cannot be ignored.

Discussion

As shown in Table 1, the number of species at any given Bermuda locality was always small and the number of individuals often so. The only species exceeding a couple of dozen at any locality was *C. tricolor,* and this always at places where *Batillaria* or similar small shells were abundant intertidally. The isolation of the Bermudas is undoubtedly one factor in the small number of species of pagurids found there. Another feature of these islands which may have even more significance, at least in limiting numbers of individuals if not species, is the general scarcity of gastropod shells so necessary for these crabs. Only at some intertidal localities could shells be called abundant, and very rarely could an empty gastropod shell be found.

The three most abundant hermits exhibit differences in requirements in which must certainly relieve competition amongst themselves. *C. tricolor* has the intertidal zone almost exclusively to itself; *Calcinus verrilli* and *Pagurus miamensis* share habitat, but are fairly well restricted to different types of shells. *C. verrilli* was taken most often in

Cerithium which has a rather large, round opening, while *P. miamensis* was found usually in the dove shell, *Pyrene* which has only a narrow, slit-like opening. Morphology seems to be the key here, for *C. verrilli* can seal off to some extent the round opening of *Cerithium,* but would be unable to withdraw its large left cheliped through the narrow opening of *Pyrene*. On the other hand, *P. miamensis* is well able to utilize the smaller dove shell, since its hands are much more slender than those of the *Calcinus,* but might have difficulty in utilizing the relatively large *Cerithium*.

Boden (1952) described the probable method by which planktonic larvae produced by Bermuda bottom fauna would tend to remain in the area. It is very likely that at least the three most common pagurids are able to maintain resident populations. Whether the remaining species are present in sufficient numbers to contribute significant numbers of larvae for repopulation, or whether they are represented at Bermuda only by a few successful migrants from the West Indies which are replaced periodically is unknown at present.

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A DEEP-WATER CORAL REEF IN THE GULF OF MEXICO

DONALD R. MOORE
Gulf Coast Research Laboratory
Ocean Springs, Mississippi

AND

HARVEY R. BULLIS, JR.
U.S. Fish and Wildlife Service
Pascagoula, Mississippi

ABSTRACT

The Fish and Wildlife Service M/V OREGON discovered by the depth recorder a peculiar structure on the continental slope 40 miles E. of the Mississippi River mouth, at depths of 230-280 fathoms. A drag across the area brought up about 300 lbs. of the deep water colonial coral, *Lophelia prolifera,* that had formed an extensive reef over half a mile long and up to 180 feet thick. This species is known to form deep water reefs in the northeastern Atlantic but this is the first *Lophelia* reef to be reported from the Americas.

Deep-water coral reefs are composed of one or two species of ramose, branching, colonial corals, foremost among which is the species *Lophelia prolifera* (Pallas). In marked contrast with shallow-water tropical corals, which do not commonly occur deeper than 25 fathoms as reefs, or deeper than 50 fathoms as individual colonies (Vaughan and Wells, 1943), the deep-water reefs are not dependent on the presence of a basal platform, and are loose and porous in character.

The deep-water reefs previously known are all in the North Atlantic. Most of them occur in the deep fjords and along the continental slope of the Norwegian coast (Ekman, 1953).

A deep-water reef in the Gulf of Mexico was discovered by the Bureau of Commercial Fisheries M/V OREGON on March 13, 1955. The vessel was cruising over the continental slope about forty nautical miles due east of the Mississippi Delta (29° 05′ N, 88° 19′W, 230 to 280 fathoms) when an unusual tracing appeared on the depth recorder. A small "hillock" showed on the graph which did not represent a typical bottom structure because a heavy line indicating solid bottom marked the base of the elevation, and light shading outlined the shape of the rise (Fig. 1).

A drag, made over the area with a shrimp trawl, contained a large mass of coral, other invertebrates, and fish. The netting of the trawl was torn and most of its contents were lost, but about three hundred

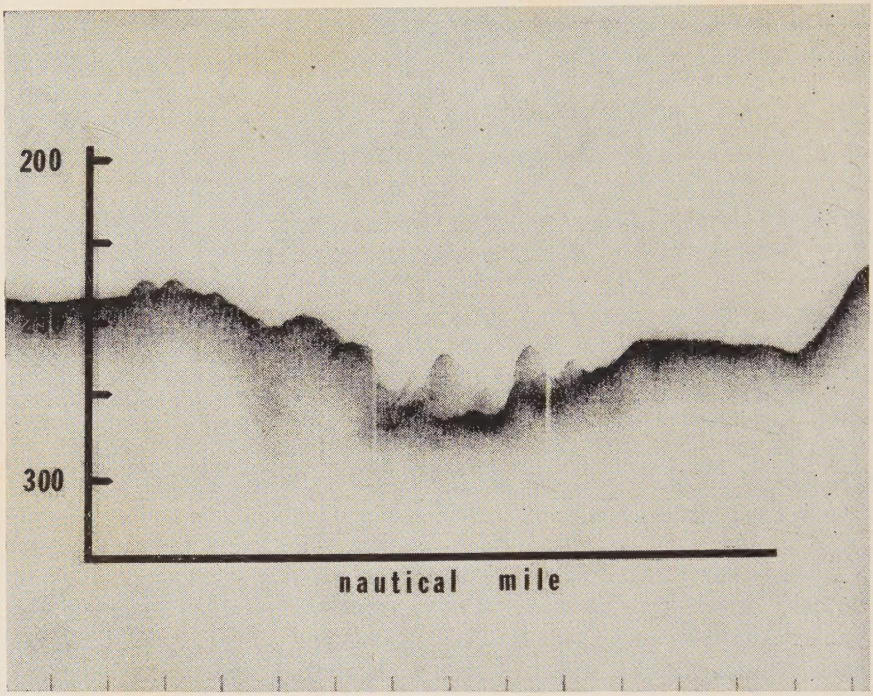

FIGURE 1. Depth recorder tracing of bottom profile at OREGON station 1283.

pounds of coral remained in the bag. A sample was brought back to the laboratory where it was identified by Moore as *Lophelia prolifera* (Fig. 2).

The data sheet for this drag (Station 1283) lists a catch of several hundred pounds of fish, shrimp, starfish, urchins, and other animals. Most of these animals probably were not associated with the coral, for part of the drag had been on gray mud bottom. A few animals were attached to the coral. Of these, one specimen of another species of coral (*Caryophyllia*) and four specimens of an undescribed species of gastropod (*Calliostoma*) were collected.

A single transect, of course, could not show the full extent of the reef, but it did indicate that a large structure is represented. The largest portion of the reef ranges up to about 180 feet thick vertically, and is over 1,000 feet long; two smaller portions are several hundred feet across and up to sixty feet thick, and lying near the major portion of the reef are several extensive, rounded mounds which appear to be

FIGURE 2. *Lophelia prolifera* (Pallas) from OREGON station 1283.

solid structures. The possibility exists that these latter may be dead portions of the reef which have had the interstices of the ramose corals filled in by silt and the calcareous remains of various shell-bearing animals. If so, the entire reef is more than 4,000 feet in length on this transect. This is not long compared with many shallow-water reefs, but the reef is of interest because it is the first deep-water reef to be reported in the West Indian region.

Figure 1 shows the relations of the parts of the reef to one another. The major portion of the reef occupies the central depression, the smaller portions appear on the right, and the solid mounds on the left.

Lophelia prolifera is widely distributed in the Atlantic and Indian Oceans. It has been known for centuries, and drawings are found in pre-Linnaean works including those of Pontippidan and Seba. The first report on its distribution, depth, and temperature range was by Wyville Thomson (1873). He stated that it was found in 150 to 600 fathoms at a temperature range of 0° to 10° C. Ekman (1953), on

the basis of living and dead material, puts the lower temperature limit at 6° C. Thomson (1873), however, stated that *Lophelia prolifera* formed a "regular bank" at PORCUPINE station 54, where the bottom temperature was minus 0.3° C at a depth of 363 fathoms. The bottom temperature taken at the reef in the Gulf of Mexico was 10.4° C, or very near the upper known limit for the species.

The species was first recorded from the West Indian region by Pourtales (1868) who described a specimen from the Straits of Florida as a new species, *Lophelia affinis*. Later records by Pourtales (1880), were obtained from the BLAKE dredgings at 294 fathoms off Grenada, and 874 fathoms just south of the west end of Puerto Rico. The CHALLENGER also dredged some fragments in 390 and 450 fathoms off the Virgin Islands (Moseley, 1881). Unpublished data obtained by explorations aboard Fish and Wildlife Service vessels include records that show that one was obtained at 34° 26′ N, 75° 42′ W, 215 fathoms, and one at 24° 13′ N, 81° 42′ W, 300 fathoms. In addition, the M/V SILVER BAY has found extensive "stony copses" of *Lophelia* on the deep plateau north of Little Bahama Bank in 400 to 600 fathoms. From these records, it can be seen that this coral is widely distributed in the West Indian region, but not enough deep-water drags have been made as yet to give a true picture of its abundance. More deep-water coral reefs will probably be discovered with more intensive exploration.

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